State of California
The Resources Agency
Department of Water Resources

ASSESSMENT OF THE RELATIONSHIP OF PROJECT OPERATIONS AND RECREATION

FINAL

R-3

Oroville Facilities Relicensing
FERC Project No. 2100

MAY 2004

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FERC Project No. 2100

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REPORT SUMMARY

The objective of this study is to determine the impacts of current Project operations and any proposed changes to operation of the Oroville Facilities on recreational use and recreational experiences of visitors engaged in various activities. Impacts to recreational uses and experiences can occur as a result of changes in reservoir pool levels, reservoir water temperature, and changes in flow rates downstream of Lake Oroville. Information gathered for this study will be used to recommend measures or facilities that may create, preserve, or enhance recreational opportunities within and in the vicinity of the study area (Subpart F, Section 4.51 of 18 CFR).

This study is one of 19 studies investigating recreation and socioeconomic issues. All of these studies are being conducted in support of relicensing the Oroville Facilities by the Federal Energy Regulatory Commission (FERC Project No. 2100). The Oroville Facilities are managed by the California Department of Water Resources (DWR) for the purposes of water supply, flood control, hydropower generation, water quality, fish and wildlife enhancement, and recreation.

This study was initiated in October 2002, and the results of this study rely in part on data collected for three other recreation studies initiated on Memorial Day Weekend, 2002: Study R-13 – *Recreation Surveys*, Study R-9 – *Existing Recreation Use*, and Study R-7 – *Reservoir Boating*. Additional data were collected as needed to complete the study tasks enumerated in the R-3 Study Plan. Field data collection for this study ended in July 2003.

Operation of the Oroville Facilities directly affects water-related activities such as swimming, boating, and fishing and can indirectly affect other activities such as picnicking, camping, or trail use. A DWR assessment of recreation in the Project area, conducted during a lengthy drought, noted that several Lake Oroville facilities have limited usefulness during times of low water (DWR 1992). During years of low runoff into the reservoir, the need to meet operational requirements can result in relatively low water levels.

PROJECT OPERATIONS ISSUES AND HISTORICAL PROJECT OPERATIONS

Review of past recreation studies conducted in the study area provided information on the effects of Oroville Facilities operations on certain facilities as observed in past years. In particular, these studies described and documented the effects of low water on boat ramps and the Loafer Creek swim beach. Review of data from the three contemporary recreation studies cited above, consisting of observations of use of recreation facilities and of boating activity and surveys of recreation visitors, provides further understanding of the effects of Oroville Facilities operations, in particular during the 2002 summer recreation season. The elevation of Lake Oroville was low enough during the latter half of that season to afford opportunities to observe effects of low water on recreation facilities that would not be evident during summers with sustained higher pool levels.

Lake Oroville Conditions

Data on daily Lake Oroville pool elevation were reviewed for the 13 years from 1990 to 2002. A particular focus has been placed on the mid-May to mid-September period of each year, when the majority of recreational boating and shoreline use occurs. These data have helped to characterize historical changes in Lake Oroville pool elevations resulting from variations in inflow and in Oroville Facilities operations.

It is evident from these data that annual and recreation-season water level fluctuations have ranged widely in past years and may differ markedly from one summer to the next. The elevation of Lake Oroville at the end of May 2003 and the two preceding years illustrates this. The pool elevation at the end of May was 898 feet (2 feet below full pool) in 2003, 837 feet in 2002, and 793 feet in 2001 (105 feet lower than in 2003). The pool elevation at the end of August was 823 feet in 2003, and 735 feet in both 2002 and 2001 (88 feet lower than in 2003). Similar variation can be seen in other consecutive years, such as 1990 through 1993, when dry years were followed by wet years.

Additional data for the 2002 summer season have been compiled on surface water temperatures in Lake Oroville. In general, these data indicate that surface temperatures across Lake Oroville range in the mid-70s to low 80s (°F) through most of the summer.

Thermalito Diversion Pool, Forebay, and Afterbay Conditions

Elevation data for the Thermalito Diversion Pool, Thermalito Forebay, and Thermalito Afterbay indicate that elevation of the Diversion Pool and Forebay is generally constant, while Thermalito Afterbay fluctuates up and down on a weekly cycle within a range of about 5 feet.

Water is released from Lake Oroville into the Diversion Pool at a relatively constant temperature of 45 to 50°F. Summer water temperatures in the Diversion Pool and Forebay are usually in the 50s while surface water temperature in most of Thermalito Afterbay warms into the 60s. Temperature may periodically reach the low 70s at the southeast portion of Thermalito Afterbay, nearest the outlet to the Feather River.

Feather River Conditions

Summer water temperatures in the Feather River within the study area are typically in the mid- to upper-50's (°F) at the upstream end and in the mid- to upper-60s at the lower end of the study area, about 13 miles downstream.

Flow rates in the upper section of the Feather River (the "low-flow" channel or LFC) were about 600 to 700 cfs most days of the 2002 season. A 1983 agreement between DWR and California Department of Fish and Game (DFG) specifies a minimum of 600 cfs is to be released into the river from the Thermalito Diversion Dam for fishery purposes. In contrast, flows in the lower section of the river, below the Thermalito Afterbay outlet, were about 1,200 cfs through May but increased steadily to about 6,500

cfs by mid-July, before dropping back to about 4,000 cfs by the end of August. Variations in these flow rates can influence the temperature profile of the river.

ASSESSMENT OF EFFECTS OF PROJECT OPERATIONS ON RECREATION USE

The effects of Oroville Facilities operations on Lake Oroville recreation activities and facilities relate primarily to reservoir drawdown, which begins in late spring to mid-summer each year. The effect of low pool levels on recreation use was assessed for this study in two distinct ways. First, attendance data dating back to 1990 were reviewed and compared with reservoir elevations at particular dates in each year to assess the relationship between low pool levels and recreational uses. Secondly, observations of recreation use, conducted for Studies R-7 and R-9 primarily during the summer 2002 recreation season, were used to describe effects of low pool levels on recreation activity and the usability of facilities.

Reservoir Elevation Effects on Attendance

Oroville Facilities recreation attendance data have been obtained for fiscal years 1974/1975 to 2000/2001 (the fiscal year begins July 1). Comparison of attendance for each fiscal year with average pool elevations for those years suggests that Lake Oroville attendance and pool elevation are related. Years in which the pool elevation was low tended to have lower attendance, and years with higher pool levels tended to have higher attendance. Recreation visitation modeling conducted for Study R-12 – *Projected Recreation Use* confirmed and quantified this relationship. However, the comparison also indicates that the years with the highest pool levels do not necessarily have the highest attendance and years with the lowest pool levels do not inevitably have the lowest attendance. It appears that other factors such as the time of year the pool level was low (i.e., a moderately high pool level maintained through the summer) and other factors unrelated to Project operations also affect attendance.

Low-Water Effects on Recreation Facilities and Activities

The pool elevation of Lake Oroville during the 2002 summer recreation season was lower than it was during most of the previous 10 years, providing the opportunity to directly observe effects of low pool levels of recreation facilities and activities. Pool elevation was 36 to 62 feet lower at the end of May, 2002 than it was in all but one year between 1993 and 2000; a similar pattern is evident when reviewing Lake Oroville pool elevations at the end of August.

Low Water Effects on Boat Ramps

Boaters were able to launch on Lake Oroville throughout the 2002 summer season and into the fall. However, usage of the larger main ramps at Spillway Recreation Area and Bidwell Canyon was impaired by mid-summer. Boaters at the Spillway location enjoyed the best low-water launching conditions due to availability of the eight-lane low-water ramp and the low-stage paved parking provided there. The main ramp at Bidwell Canyon progressively narrows from the middle of the ramp to its lower end, reducing the number of lanes available as the reservoir level falls. By late summer, boaters were

using an adjacent unpaved two-lane ramp with a gravel parking area. The Lime Saddle Ramp does not include a separate low-water ramp and was difficult to use due to low water and muddy conditions by the end of summer. The Enterprise Boat Ramp (BR) closed in mid-June, and the Loafer Creek ramp became unusable by late July.

The reduction in the number of launch ramps and lanes available as Lake Oroville is drawn down each year may result in more boaters having to wait to launch or retrieve their boats, though wait times do not appear to be excessive (generally 10 minutes or less) at most times.

Historically, both the Loafer Creek and Enterprise BRs have often been unusable by mid-summer. Enterprise Ramp has been unusable for more than half and Loafer Creek ramp about one-third of summer boating season days (May 15–September 15) from 1990 to 2002. The main launch ramps at Lime Saddle and Spillway were also unusable during parts of some years from 1990 to 2002, although this occurred less frequently than at Loafer Creek BR or Enterprise BR and the period of closure was usually limited to the last 35 to 40 days of the season. In late 2002, both of those ramps were extended to reach elevations 25 to 30 feet lower. The ramps will now be usable during all but the lowest pool levels (below 700 feet) that occur some years during late fall and winter. The ramp at Bidwell Canyon has also been paved to a similar elevation.

Low-Water Effects on Car-Top Boat Ramps

The primary function of the car-top boat ramps is to provide opportunities for hand launching of boats (e.g., canoes and kayaks) and access to the shoreline for non-boaters. Most are situated on more remote parts of the lake and provide a less-developed setting than the main boat ramps. The sites also are used for a limited amount of trailer-launching, mostly of small fishing boats, but this is not officially allowed.

The car-top boat ramps (essentially old road beds) vary in respect to what pool elevation affects them, depending on the slope of the land and the length and condition of the old road beds that provide access to the shore and water. Three of these areas feature steep shorelines making hand launching difficult at low water levels and limiting other shoreline use. During 2002, the Vinton Gulch facility was only marginally usable for trailer launching the entire year, as the paved road was never in the water. The site continued to provide some opportunity for hand launching of boats and bank fishing into mid-June, until the pool elevation fell below about 825 feet. Similar to Vinton Gulch, pool levels during 2002 allowed only early-summer trailer-launching of boats at the Nelson Bar Car-Top BR. By mid-June, visitors wishing to hand launch boats or fish or swim from the shore had to negotiate a steep and rocky shoreline. The Dark Canyon Car-Top BR facility, with its access road running for some distance along the side of Dark Canyon cove, was usable for hand and trailer launching into early August, until the reservoir was below about 765 feet.

Unlike the areas just described, the less-steep shoreline of the Foreman Creek Car-Top BR attracts shoreline use by both boaters and non-boaters. However, the road bed was out of the water by early August, when the reservoir elevation fell below about 765 feet, and use of the area was observed to be low after that time. The road bed at the Stringtown Car-Top BR extends far enough to have allowed use for launching into early August. The county road to Stringtown Car-Top BR, however, is long and winding, and few boat trailers were observed in the area. Shoreline use appeared to occur until the reservoir elevation was below about 800 feet, after which time the steepness of the shore and distance to the water made the area less desirable to visitors.

Low-Water Effects on Boat-in Campsites

Light use of some of the boat-in campsites was observed at the start of the 2002 summer recreation season, when the reservoir was about 60 feet below full pool. At that elevation, the necessity of hiking up the steep shoreline to the sites was not enough to entirely discourage use. By late June, the reservoir elevation had fallen an additional 23 feet and virtually no use of the boat-in campsites was observed thereafter.

Low-Water Effects on Swimming Access

The sole swimming facility on Lake Oroville, at the Loafer Creek day-use area, was not usable at any point during the 2002 summer season. The facility is designed to be used at pool elevations within about 50 feet of full pool. Swimming at other locations, particularly at car-top boat ramp areas, appeared to continue throughout the summer but became more difficult at most areas as the pool level fell (due to steep and muddy shorelines). The gentler topography at the Foreman Creek Car-Top BR provided the latest swimming opportunities of the season, but often had limited desirability because of muddy shorelines and periodically turbid water.

Effects of Water Temperature on Swimming

Investigations into the effects of water temperature on swimming are focused on the LFC of the Feather River, Thermalito Forebay, and Thermalito Afterbay. Swimmers can access the river from Riverbend Park and other riverbank locations but are often deterred from using the river for swimming because of the low temperature of the water (around 60°F) throughout the summer. Water temperature data for the lagoon on which the popular swim beach at the North Thermalito Forebay DUA is located show the surface water periodically warms into the mid-70s but the deep water (3–5 feet down) remains in the 60s.

Some swimming was observed at the South Thermalito Forebay and Thermalito Afterbay (Monument Hill) facilities, but these areas were primarily used by boaters, personal watercraft (PWC) users, and bank anglers. No temperature data for those specific locations have been obtained, but data from nearby locations suggest that summer temperatures are no higher than about 65 to 68°F.

Effect of Flow Rates and Temperatures on Fishing

The temperature regime maintained in the Feather River within the Project area is primarily determined by the needs of cold water fish species such as salmon and steelhead, in both the Feather River Fish Hatchery and the river itself. The continued presence of these important species, which are the most popular targets for anglers on the river, are largely dependent on the adequate flows of sufficiently cold water, which are enhanced by current operations. Fisheries studies being conducted under the direction of the Environmental Work Group are investigating the potential for operational changes that would provide increased flows in the river to further improve fish habitat and survival. The Environmental Work Group is also investigating the potential for operational changes that may provide warmer water in the River, Forebay, and Afterbay, as desired by agricultural diverters and some recreational users of the water, while still meeting the needs of the coldwater fisheries.

The primary effect of reservoir operations on fishing at Lake Oroville relates to the effects of reservoir drawdown on shoreline and boat access as described above. A fisheries study being conducted under the purview of the Environmental Work Group is also investigating the effect of seasonal reservoir drawdown on 1) the availability of warmwater fish spawning and rearing habitat and frequency of nest mortality, and 2) distribution and amount of salmonid spawning and rearing habitat and accessibility to upstream tributary habitat. Lake Oroville's temperature profile is similar from year to year, despite reservoir drawdown and surface elevation differences. However, during periods of lower reservoir elevations, the volume of cold water in the pool available for release downstream is reduced.

ASSESSMENT OF PROJECT OPERATIONS ON RECREATION EXPERIENCES

The recreation facility effects described above might be expected to have significant effects on recreation experiences. However, the character, magnitude, and importance of those effects on visitors' recreation experiences were not immediately apparent. For this reason, the several survey efforts conducted in the study area were, in part, directed at learning more from visitors about the specific effects of low water levels and other operational factors on the recreation experiences they desired.

A series of survey questions asked Project area visitors whether they considered certain issues to be a problem in the recreation area they visited. The responses indicate that about 40 to 45 percent of Lake Oroville visitors considered water level fluctuation, exposed land during low water, and shallow areas during low water to be at least "a moderate problem." About one-quarter of all visitors surveyed considered each of these to be "a big problem."

Visitors who participated in the On-Site and Mail-Back Surveys had the opportunity to provide additional written comments on their survey booklets. The invitation to provide additional comments was intended to give visitors an opportunity to comment further on the topics most important to them and to provide more detailed information on their attitudes and opinions.

Nearly half of all visitors contacted on-site and about 70 percent of those who returned the Mail-Back Survey provided additional comments. Roughly one-third of these comments expressed concerns related in some way to low water levels. Many provided specific complaints or concerns about the effects of low water on their use and enjoyment of recreational facilities. The comments provided useful and direct insight into the effects of Oroville Facilities operations on recreation experiences. A few visitors suggested changes that they believed would improve their recreation experiences. Several examples of each type of comment are provided in this report.

ASSESSMENT OF EFFECTS OF FUTURE OPERATIONAL SCENARIOS

This portion of the assessment relies in large part on the results of operations modeling conducted by the Engineering and Operations Work Group. This modeling quantifies the likely future pool levels and temperatures and river flows and temperatures that will occur during different water-year types (dry, normal, wet) with different water release schedules and other operational changes.

Since 1990, Lake Oroville has experienced long periods of very low water (below 750 foot elevation) as well as long periods of high water (above 850 feet). A key focus in evaluating the operations modeling results was on the timing and amount of reservoir drawdown in the future. In particular, low pool levels occurring during the summer boating season (prior to mid-September) and pool levels below 800 feet (100 feet below full pool) are of interest due to the potential effects on recreation.

Operations Modeling Results and Recreation Implications

The operations modeling simulates Lake Oroville pool levels and indicates the potential for certain operational changes to affect Feather River flows and temperatures. The Feather River results are supplemented with data from observations and informal interviews collected during a three-day period in which typical water releases to the LFC were more than doubled.

Model Simulations Related to Lake Oroville Pool Levels

The Statewide model, CALSIM II, is the operations model that, among other things, simulates Lake Oroville's reservoir pool levels. CALSIM II uses inflows to Lake Oroville and local accretions and depletions that were developed by modifying historic hydrologic data. The modified data represents a synthetic data set for the years 1922 to 1994. The model uses the synthetic data as input to simulate Lake Oroville elevations with different levels of water demands. Model runs in which maximum water deliveries to State Water Project (SWP) contractors are assumed indicate that there is a nearly 100 percent probability that the boat ramps at Spillway, Lime Saddle, and Bidwell Canyon will be usable at the end of May, the traditional start of the peak boating season, in any given year. There is about a 92 percent probability that these ramps would be usable at the end of August, after which boating activity typically declines. Because of their shorter reach, the likelihood is lower that the Loafer Creek and Enterprise ramps would be usable by mid and late-summer. Model runs in which SWP

water deliveries are reduced by about 30 percent from the maximum substantially increase the probabilities that ramps will be usable, particularly later in the summer and fall.

The same model runs also allow simulations of Lake Oroville pool levels during different water year types. The results indicate that, with the assumption of maximum water deliveries, all of the boat ramps with the exception of the Enterprise BR would be usable through the end of August during all wet and above-normal years and most below-normal years. During dry years, the results indicate that low water levels would cause the closure of Enterprise BR by the end of June and Loafer Creek BR by the end of August, while the other three ramps would remain usable all season. During some critically dry years, in particular those following dry or critically dry years, all ramps would be closed by the end of August, but would be open most of the peak boating season.

Model runs using the same synthetic historical hydrologic data as above, but comparing current (2002) and future (2020) level of development/land use in the SWP service area, were used to simulate whether Lake Oroville elevations are likely to differ from past levels. The results indicate that reservoir levels will be similar in 2020 to past levels.

Model Runs Related to Feather River Flows and Temperatures

Modeling related to the Feather River investigated the effect of different release flows and temperatures on water temperature in the Feather River downstream of the Thermalito Afterbay outlet. The results indicated that higher flows (4,200 cfs vs. 1,000 cfs) reduced temperatures only a few degrees within the study area under typical summer meteorological conditions. Temperatures were affected more substantially under atypically hot weather conditions (daytime high temperatures of 110°F). Increasing the temperature of water released at the outlet, as expected, increased water temperature in the river; however, the results indicate that the water would warm only about an additional 1 to 3°F within the Project area under typical summer meteorological conditions regardless of the outlet flow temperature.

Observations of temperature and recreation use effects during the increased flow event on the LFC indicate that water temperatures were affected only slightly and temporarily, and angling activity (the primary recreation use of the LFC) increased. Some anglers felt the increased flow made wading more difficult or otherwise hurt their angling success, but most felt the increased flow had improved angling, or would do so in the longer term. There also appears to be some potential benefits of the increased flows for non-motorized boaters.

Recreation Modeling Results and Recreation Implications

Recreation modeling completed for Study R-12 – *Projected Recreation Use* quantified the effects of specific Lake Oroville pool levels on attendance at Lake Oroville and Thermalito Forebay. A significant relationship was found between past reservoir pool

level and attendance at Lake Oroville, with low pool levels having a negative effect on attendance. Operations modeling results that simulate future Lake Oroville elevations may serve as input into this recreation attendance model to permit estimates of the effects of various future operational scenarios on Lake Oroville attendance. The very slight differences predicted for Lake Oroville elevations in 2020 as compared to the present, both for specific months and annually, equate to essentially no significant difference in Lake Oroville attendance due to future pool elevation changes.

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ACRONYMS AND ABBREVIATIONS

af	acre-feet
af/day	acre-feet per day
BIC	Boat-In Campsites
BR	Boat Ramp
cfs	cubic feet per second
CFR	Code of Federal Regulations
CSUC	California State University–Chico
Delta	Sacramento–San Joaquin Delta
DFG	California Department of Fish and Game
DPR	California Department of Parks and Recreation
DUA	Day Use Area
DWR	California Department of Water Resources
FERC	Federal Energy Regulatory Commission
LOSRA	Lake Oroville State Recreation Area
maf	million acre-feet
msl	mean sea level
MW	megawatt
NOAA	National Oceanic and Atmospheric Administration
NOAA Fisheries	NOAA National Marine Fisheries Service
OWA	Oroville Wildlife Area
SWP	State Water Project
SWRCB	State Water Resources Control Board
USACE	U.S. Army Corps of Engineers

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1.0 INTRODUCTION

1.1 BACKGROUND

Oroville Facilities operations specifically reviewed herein include the operation of Oroville Dam and its associated power plant, and of pumping, storage, conveyance, and generating facilities associated with Thermalito Forebay and Thermalito Afterbay downstream of Oroville Dam. These facilities operate together to move water and generate electricity. Operation of these facilities has a variety of effects on the waters of the project.

The principal effect of Oroville Facilities operations on Lake Oroville is fluctuation in the reservoir's pool level. Several factors can affect the inflow to and outflow from Lake Oroville, and the resulting pool level fluctuation during the recreation season may differ widely from year to year. For example, during the 10 years before the 2002 study year, seasonal elevation fluctuated as little as 62 feet (in 1996) and as much as 178 feet (in 1993).

Oroville Facilities operations affect water temperatures and pool levels at impoundments downstream of Lake Oroville—Thermalito Diversion Pool, Thermalito Forebay, and Thermalito Afterbay. Water temperatures and flows in the Feather River are also affected.

Water-based recreation activities at Lake Oroville, such as swimming, boating, and fishing, are directly affected by changes in water levels, temperatures, and flow rates. Shoreline access becomes more difficult for both boaters and non-boaters in many areas as the water elevation falls, and the surface area available for boating is reduced. Activities such as picnicking, camping, and trail use can be affected indirectly. The California Department of Water Resource's *Assessment of Recreation at Lake Oroville* (DWR 1992) identified several recreation facilities that have limited usefulness below certain pool elevations. For these reasons, the amount and timing of reduction of the reservoir's elevation may have significant cumulative effects on recreation.

1.2 ISSUES ADDRESSED

About 150 specific issues, all of which were categorized into 6 recreation-related Issue Statements, were identified during early stages of the Oroville Facilities study planning process. This study is intended to address the individual issues encapsulated by Issue Statement R3—*Effects Of Facilities Operations On Recreation And Socioeconomic Opportunities*. Specifically, the study will also address Issues RE44, 50, 51, and 63:

- RE44—Consider effects of changes in flow rates on recreational fishing.
- RE50—What are the potential impacts of Lake Oroville fluctuation zone and surface elevation change on recreation opportunities and on fish and wildlife habitat?

- RE51—Lake levels drop too low in the summer for boaters.
- RE63—What is the recreational value of hunting and fishing on project lands and how can they be enhanced?

1.3 DESCRIPTION OF FACILITIES

The Oroville Facilities were developed as part of the State Water Project (SWP), a water storage and delivery system of reservoirs, aqueducts, power plants, and pumping plants. The main purpose of the SWP is to store and distribute water to supplement the needs of urban and agricultural water users in Northern California, the San Francisco Bay Area, the San Joaquin Valley, and Southern California. The Oroville Facilities are also operated to provide flood management, generate power, improve water quality in the Sacramento–San Joaquin Delta (Delta), provide recreation, and enhance fish and wildlife.

Federal Energy Regulatory Commission (FERC) Project No. 2100 encompasses 41,100 acres. It includes all of the following:

- Oroville Dam;
- Lake Oroville;
- Three power plants (Hyatt Pumping-Generating Plant, Thermalito Diversion Dam Powerplant, and Thermalito Pumping-Generating Plant);
- Thermalito Diversion Dam;
- The Feather River Fish Hatchery;
- The Fish Barrier Dam;
- The Thermalito Power Canal;
- The Oroville Wildlife Area (OWA);
- Thermalito Forebay;
- Thermalito Forebay Dam;
- Thermalito Afterbay;
- Thermalito Afterbay Dam;
- Transmission lines; and
- A number of recreational facilities.

An overview of these facilities is provided in Figure 1.3-1. Oroville Dam, along with two small saddle dams, impounds Lake Oroville, a reservoir with capacity of more than 3.5 million acre-feet (maf) and a surface area of 15,810 acres at its normal maximum operating level of 900 feet above man sea level (msl).

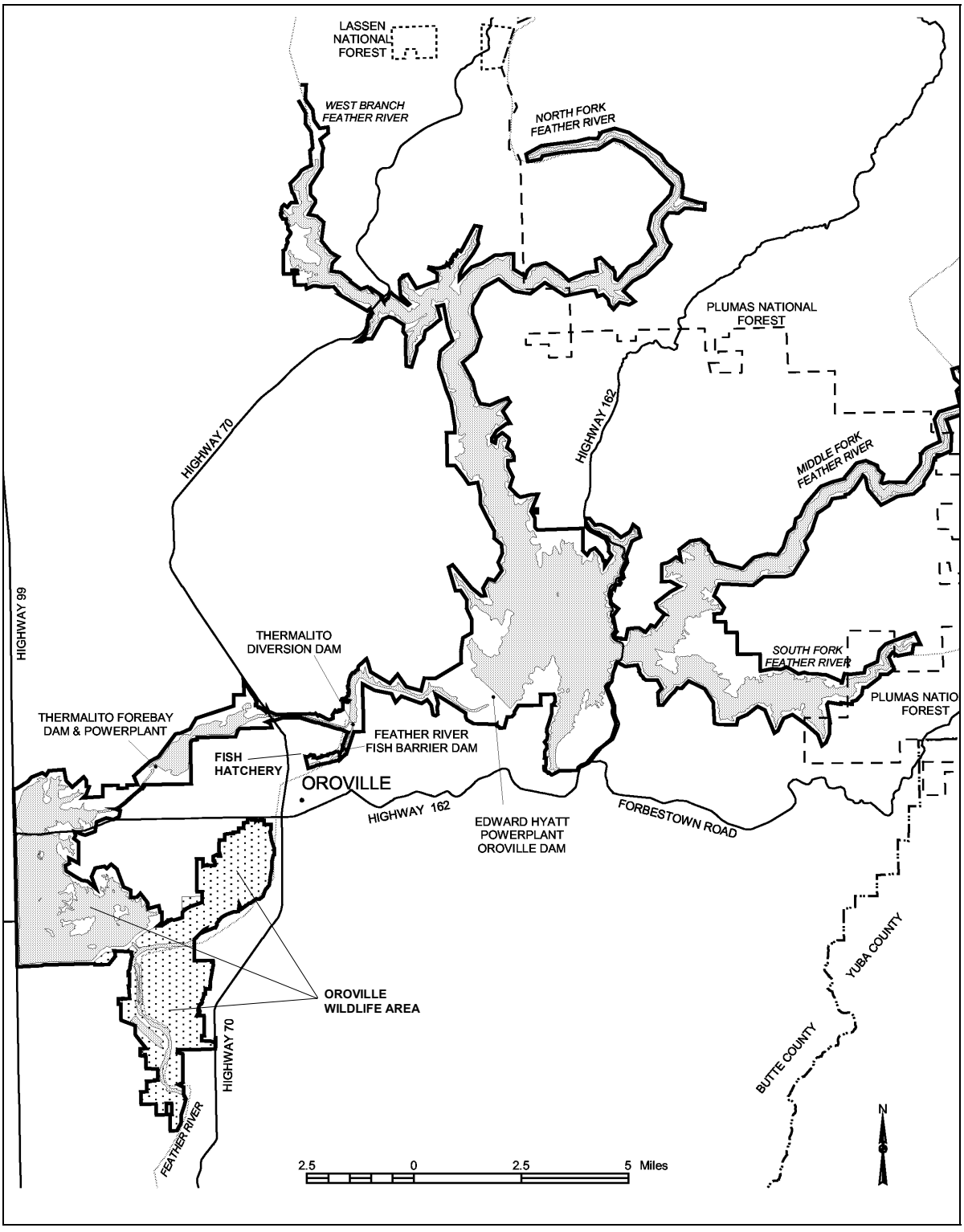

Figure 1.3-1. Oroville Facilities FERC Project 2100 boundary.

The hydroelectric facilities have a combined licensed generating capacity of approximately 762 megawatts (MW). The Hyatt Pumping-Generating Plant is the largest of the three power plants with a capacity of 645 MW. Water from the six-unit underground power plant (three conventional generating and three pumping-generating units) is discharged through two tunnels into the Feather River just downstream of Oroville Dam. The plant has generating and pumping flow capacities of 16,950 cubic feet per second (cfs) and 5,610 cfs, respectively. Other generation facilities include the 3-MW Thermalito Diversion Dam Powerplant and the 114-MW Thermalito Pumping-Generating Plant.

Thermalito Diversion Dam, 4 miles downstream of Oroville Dam, creates a tailwater pool for the Hyatt Pumping-Generating Plant and is used to divert water to the Thermalito Power Canal. The Thermalito Diversion Dam Powerplant is located on the left abutment of the Diversion Dam. This power plant releases a maximum of 615 cfs of water into the river.

The Thermalito Power Canal is a 10,000-foot-long channel designed to convey generating flows of 16,900 cfs to Thermalito Forebay and pump-back flows to the Hyatt Pumping-Generating Plant. Thermalito Forebay is an offstream regulating reservoir for the 114-MW Thermalito Pumping-Generating Plant. The Thermalito Pumping-Generating Plant is designed to operate in tandem with the Hyatt Pumping-Generating Plant and has generating and pump-back flow capacities of 17,400 cfs and 9,120 cfs, respectively. When in generating mode, the Thermalito Pumping-Generating Plant discharges into Thermalito Afterbay, which is contained by a 42,000-foot-long earthfill dam. The Afterbay is used to release water into the Feather River downstream of the Oroville Facilities, and helps regulate the power system, provides storage for pump-back operations, and provides recreational opportunities. Several local irrigation districts receive water from Thermalito Afterbay.

The Fish Barrier Dam is downstream of Thermalito Diversion Dam and immediately upstream of the Feather River Fish Hatchery. The flow over the dam maintains fish habitat in the low-flow channel (LFC) of the Feather River between the dam and the Thermalito Afterbay Outlet, and provides attraction flow for the hatchery. The hatchery was intended to compensate for spawning grounds lost to returning salmon and steelhead trout from the construction of Oroville Dam. The hatchery accommodates an average of 8,000 adult fish annually.

The Oroville Facilities support a wide variety of recreational opportunities. These opportunities include boating (several types), fishing (several types), fully developed and primitive camping (including boat-in and floating sites), picnicking, swimming, horseback riding, hiking, off-road bicycle riding, wildlife watching, and hunting. There are also visitor information sites with cultural and informational displays about the developed facilities and the natural environment. There are major recreation facilities at Lime Saddle, Loafer Creek, Bidwell Canyon, Spillway, and North and South Thermalito

Forebay. Lake Oroville has two full-service marinas, five car-top boat ramps, ten floating campsites, and seven dispersed floating toilets. There are also recreation facilities at the Lake Oroville Visitors Center and the OWA.

The OWA comprises approximately 11,000 acres west of Oroville that is managed for wildlife habitat and recreational activities. It includes Thermalito Afterbay and surrounding lands (approximately 6,000 acres) along with 5,000 acres adjoining the Feather River. The 5,000-acre area straddles 12 miles of the Feather River, which includes willow and cottonwood lined ponds, islands, and channels. Recreational opportunities include dispersed recreation (hunting, fishing, and bird watching); recreational activities also take place at developed sites (the Monument Hill Day Use Area (DUA), model airplane grounds, and three boat launches on Thermalito Afterbay and two on the river) and in two primitive camping areas. The California Department of Fish and Game's (DFG) habitat enhancement program includes a wood duck nest-box program and dry-land farming for nesting cover and improved wildlife forage. Limited gravel extraction also occurs in a number of locations.

1.4 CURRENT OPERATIONAL CONSTRAINTS

Operation of the Oroville Facilities varies seasonally, weekly, and hourly, depending on hydrology and the objectives that the California Department of Water Resources (DWR) is trying to meet. Typically, releases to the Feather River are managed to conserve water while meeting a variety of water delivery requirements, including flow, temperature, fisheries, recreation, diversion, and water quality. Lake Oroville stores winter and spring runoff for release to the Feather River as necessary for project purposes. Meeting the water supply objectives of the SWP has always been the primary consideration for determining Oroville Facilities operation (within the regulatory constraints specified for flood control, instream fisheries, and downstream uses). Power production is scheduled within the boundaries specified by the water operations criteria noted above. Annual operations planning is conducted for multiyear carryover. The current methodology is to retain half of the Lake Oroville storage above a specific level for subsequent years. Currently, that level has been established at 1 maf; however, this does not limit drawdown of the reservoir below that level. If hydrology is drier than expected or requirements are greater than expected, additional water would be released from Lake Oroville. The operations plan is updated regularly to reflect changes in hydrology and downstream operations. Typically, Lake Oroville is filled to its maximum annual level, 900 feet above mean sea level (msl), in June; it then can be lowered to its minimum level in December or January as necessary to meet downstream requirements. In drier years, the reservoir may be drawn down more and may not fill to the desired levels during the following spring. Project operations are directly constrained by downstream operational constraints and flood management criteria as described below.

1.4.1 Downstream Operation

An August 1983 agreement between DWR and DFG entitled "Agreement Concerning the Operation of the Oroville Division of the State Water Project for Management of Fish & Wildlife" (DWR 1983) sets criteria and objectives for flow and temperatures in the LFC and the reach of the Feather River between Thermalito Afterbay and Verona. This agreement: (1) establishes minimum flows between the Thermalito Afterbay Outlet and Verona that vary by water year type; (2) requires flow changes under 2,500 cfs to be reduced by no more than 200 cfs during any 24-hour period, except for flood management, failures, etc.; (3) requires flow stability during the peak of the fall-run Chinook spawning season; and (4) sets an objective of suitable temperature conditions during the fall months for salmon and during the later spring/summer for shad and striped bass.

1.4.1.1 Instream Flow Requirements

The Oroville Facilities are operated to meet minimum flows in the Lower Feather River as established by the 1983 agreement (see above). The agreement specifies that the Oroville Facilities release a minimum of 600 cfs into the Feather River from Thermalito Diversion Dam for fisheries purposes. This is the total volume of flows from the diversion dam outlet, the diversion dam power plant, and the Feather River Fish Hatchery pipeline.

Generally, the instream flow requirements below Thermalito Afterbay are 1,700 cfs from October through March, and 1,000 cfs from April through September. However, if runoff for the previous April–July period is less than 1,942,000 acre-feet (af), which is the 1911–1960 mean unimpaired runoff near Oroville, the minimum flow can be reduced to 1,200 cfs from October to February, and 1,000 cfs for March. A maximum flow of 2,500 cfs is maintained from October 15 through November 30 to prevent spawning in overbank areas that might become dewatered.

1.4.1.2 Temperature Requirements

The Thermalito Diversion Pool provides the water supply for the Feather River Fish Hatchery. The hatchery objectives are 52°F for September, 51°F for October and November, 55°F for December through March, 51°F for April through May 15, 55°F for the last half of May, 56°F for June 1–15, 60°F for June 16 through August 15, and 58°F for August 16–31. A temperature range of plus or minus 4°F is allowed for objectives from April through November.

There are several temperature objectives for the Feather River downstream of the Thermalito Afterbay Outlet. During the fall months, after September 15, the temperatures must be suitable for fall-run Chinook salmon. From May through August, they must also be suitable for shad, striped bass, and other warmwater fish.

National Oceanic and Atmospheric Administration–Fisheries (NOAA Fisheries) has also established an explicit criterion for steelhead trout and spring-run Chinook salmon, memorialized in a biological opinion on the effects of the Central Valley Project and SWP on Central Valley spring-run Chinook and steelhead. As a reasonable and prudent measure, DWR is required to control water temperature at Feather River mile 61.6 (Robinson Riffle in the LFC) from June 1 through September 30. This measure attempts to maintain water temperatures at less than or equal to 65°F on a daily average. The requirement is not intended to preclude pump-back operations at the Oroville Facilities needed to assist the State of California with supplying energy during periods when the California Independent System Operator anticipates a Stage 2 or higher alert.

The hatchery and river water temperature objectives sometimes conflict with temperatures desired by agricultural diverters. Under existing agreements, DWR provides water for the Feather River Service Area contractors. The contractors claim a need for warmer water during spring and summer for rice germination and growth (i.e., 65°F from approximately April through mid-May, and 59°F during the remainder of the growing season). There is no obligation for DWR to meet the rice water temperature goals. However, to the extent practical, DWR does use its operational flexibility to accommodate the Feather River Service Area contractors' temperature goals.

1.4.1.3 Water Diversions

Monthly irrigation diversions of up to 190,000 af (July 2002) are made from the Thermalito Complex during the May–August irrigation season. The total annual entitlement of the Butte and Sutter County agricultural users is approximately 1 maf. After these local demands are met, flows into the lower Feather River continue into the Sacramento River and into the Delta. In the northwestern portion of the Delta, water is pumped into the North Bay Aqueduct. In the south Delta, water is diverted into Clifton Court Forebay where the water is stored until it is pumped into the California Aqueduct.

1.4.1.4 Water Quality

Flows through the Delta are maintained to meet Bay-Delta water quality standards arising from DWR's water rights permits. These standards are designed to meet several water quality objectives such as salinity, Delta outflow, river flows, and export limits. The purpose of these objectives is to attain the highest reasonable water quality considering all demands being made on Bay-Delta waters. In particular, they protect a wide range of fish and wildlife including Chinook salmon, Delta smelt, a variety of sport fisheries, and the habitat of estuarine-dependent species.

1.4.2 Flood Management

The Oroville Facilities are an integral component of the flood management system for the Sacramento Valley. During wintertime, the Oroville Facilities are operated under

flood control requirements specified by the U.S. Army Corps of Engineers (USACE). Under these requirements, Lake Oroville is operated to maintain up to 750,000 af of storage space to allow for the capture of significant inflows. Flood control releases are based on the release schedule in the flood control diagram or the emergency spillway release diagram prepared by USACE, whichever requires the greater release. Decisions regarding such releases are made in consultation with USACE.

The flood control requirements are designed for multiple uses of reservoir space. When flood management space is not required to accomplish flood management objectives, the reservoir space can be used for storing water. From October through March, the maximum allowable storage limit (the point at which specific flood releases would have to be made) varies from about 2.8 maf to 3.2 maf to ensure adequate space in Lake Oroville to handle flood flows. The actual encroachment demarcation is based on a wetness index, computed from accumulated basin precipitation. This allows higher levels in the reservoir when the prevailing hydrology is dry while maintaining adequate flood protection. When the wetness index is high in the basin (i.e., high potential runoff from the watershed above Lake Oroville), the flood management space required is at its greatest amount to provide the necessary flood protection. From April through June, the maximum allowable storage limit is increased as the flooding potential decreases, which allows capture of the higher spring flows for use later in the year. During September, the maximum allowable storage decreases again to prepare for the next flood season. During flood events, actual storage may encroach into the flood reservation zone to prevent or minimize downstream flooding along the Feather River.

2.0 NEED FOR STUDY

This study assesses the relationship between Oroville Facilities operations and recreation. This study is needed to determine the impacts of current project operations and any proposed changes to operations on recreational use and recreational experiences of visitors engaged in various activities. Impacts to recreational uses and experiences can occur as a result of changes in reservoir pool levels, reservoir water temperature, and changes in flow rates downstream of Lake Oroville. Information gathered for this study will be used to recommend measures or facilities that may create, preserve, or enhance recreational opportunities within and in the vicinity of the study area.

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3.0 STUDY OBJECTIVES

The main purpose of Study R-3 – *Assessment of the Relationship of Project Operations and Recreation* is to determine the effects of current conditions and of possible proposed changes to Oroville Facilities operations on recreational use and the recreational experiences of visitors during various activities. The R-3 Study Plan describes specific tasks designed to accomplish several specific objectives:

- Gain a full understanding of the extent of recreation facilities and water bodies affected by low pool levels;
- Develop a database of historical project operations including pool elevations, water temperature, and flow rates in the Feather River;
- Provide a historical perspective (1990–2002) on how low pool levels affect recreational use and attendance;
- Assess project operations' effects on boat ramps, boat-in campsites, and swimming access;
- Assess effects of water temperature on swimming;
- Assess effects of flow rates and water temperatures on fishing;
- Assess effects of project operations on recreation experiences; and
- Assess effects of future operational scenarios on recreational use.

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4.0 METHODOLOGY

4.1 STUDY AREA

The study area includes Lake Oroville, Thermalito Diversion Pool, Thermalito Forebay, Thermalito Afterbay, the lands and waters within and adjacent to (within 0.25 mile of) the FERC project boundary, and adjacent lands, facilities, and areas with a clear project nexus. The following facilities are the primary focus of this report (Figure 4.1-1):

Lake Oroville Boat Ramps

- Spillway Boat Ramp (BR)
- Bidwell Canyon BR
- Loafer Creek BR
- Lime Saddle BR
- Enterprise BR

Thermalito Forebay and Thermalito Afterbay Boat Ramps

- North Thermalito Forebay BR
- South Thermalito Forebay BR
- Monument Hill BR (Thermalito Afterbay)
- Wilbur Road BR (Thermalito Afterbay)

Car-top Boat Launch Ramps

- Nelson Bar Car-Top BR (Lake Oroville)
- Foreman Creek Car-Top BR (Lake Oroville)
- Dark Canyon Car-Top BR (Lake Oroville)
- Vinton Gulch Car-Top BR (Lake Oroville)
- Stringtown Car-Top BR (Lake Oroville)
- Larkin Road Car-Top BR (Thermalito Afterbay)

Boat-in Campsites

- Craig Saddle Boat-In Campsite (BIC)
- Foreman Creek BIC
- Bloomer Area BICs (includes group camps)
- Goat Ranch BIC

Day Use Areas with Swim Beaches

- Loafer Creek DUA (Lake Oroville)
- North Thermalito Forebay DUA
- Monument Hill DUA (Thermalito Afterbay)

Recreational use and experiences at other facilities may also be indirectly affected by project operations to some degree. For example, when reservoir pool levels are low, visitors to day-use areas without beach facilities (such as facilities adjacent to the

Bidwell Canyon, Spillway, and Lime Saddle BRs) and users of drive-in campgrounds may have difficulty accessing the shoreline. Also, visitors using dispersed sites, such as anglers accessing the Feather River within the OWA, may be affected by project operations that result in higher or lower river temperatures and flows. Attitudes and opinions of such dispersed users and anglers are addressed in Study R-13 – *Recreation Surveys* and, where relevant, are reported here.

4.2 RESEARCH ON PROJECT OPERATIONS AND OPERATIONS ISSUES

Work completed during the preparation of background reports and development of study plans for the Oroville Facilities Relicensing provided a broad understanding of the effects of project operations on recreation. It was recognized that certain Lake Oroville recreation facilities have limited usefulness below certain surface elevations, and that those elevations typically occur at some point during almost every year, often during the summer recreation season. It was further recognized that elevation changes and low water temperatures had some degree of impact on recreation at Thermalito Forebay, Thermalito Afterbay, and on the Feather River below Oroville Dam.

Ongoing research as detailed below has been conducted to further describe and document the effects of Oroville Facilities operations on recreation.

4.2.1 Identification of Recreation Facilities and Water Bodies Affected by Project Operations

Data from several other relicensing studies conducted under the direction of the Recreation and Socioeconomics Work Group were reviewed for information about the extent of recreation facilities and water bodies that may be affected by low pool levels and other project operations.

Study R-7– *Reservoir Boating* included observations of boating activity conducted from research boats surveying Lake Oroville between May 2002 and August 2003. These observations documented changes in boating activity through that period, as reservoir levels decreased. They also documented changes in access to and use of car-top boat launches and other shoreline sites by both boaters and non-boaters.

Figure 4.1-1. Oroville Facilities recreation sites discussed.

11 x 17 insert

Figure 4.1-1. Oroville Facilities recreation sites discussed.

11 x 17 insert

Study R-9 – *Existing Recreation Use* included observations of the numbers and types of visitors using recreation facilities from May, 2002 to May, 2003. Numbers and types of visitors were counted at all recreation sites, with approximately 20–40 observations at most sites during that period. These observations provided more extensive information on changes in the use of facilities through the summer than information collected for Study R-7 – *Reservoir Boating*. Observers noted when facilities such as the primary and car-top boat ramps became less usable or were closed to use. The study included both written and photographic documentation of conditions.

Study R-13 – *Recreation Surveys* included an On-Site Survey for which more than 2,500 visitors completed a survey booklet. Select data from that survey and a follow-up Mail-Back Survey, which was completed by about 1,100 visitors, directly indicated visitors' perceptions of low water levels and other aspects of Oroville Facilities operations. Special emphasis was placed on reviewing survey respondents' written comments, many of which expressed concerns and complaints related to low water levels and the effects of low reservoir elevations on recreation facilities and visitors' recreation experiences.

Lastly, Study R-10 – *Recreation Facility and Condition Inventory* included a description of the condition of facilities in the study area and a discussion of recreation resources affected by reservoir pool levels.

Several existing documents were also reviewed for information on the operational effects of the Oroville Facilities on recreation.

In August 1992, DWR published *Assessment of Recreation at Lake Oroville* (DWR 1992). The assessment was conducted in the midst of a third consecutive recreation season of extremely low water levels in Lake Oroville, resulting from drought. The report describes existing recreation facilities and the effects of low water levels on use of the facilities, in some cases documenting these effects with photographs.

In 1996, DWR contracted with the University Foundation at California State University–Chico (CSUC), for the services of the Department of Recreation and Parks Management. CSUC conducted a study that measured attendance and described recreational use at Lake Oroville State Recreation Area (LOSRA) and Thermalito Afterbay facilities. Most pertinent to the current study were observations made during 1996 at formal and informal swimming locations and the effect of low water levels on car-top BRs and other facilities.

4.2.2 Compilation of Project Operations Data

Information on Oroville Facilities operations, including water temperature and elevation data and flow rates, was obtained from several DWR websites. The Division of Flood Management provides access to a wide range of DWR operational and hydrologic data, including daily Lake Oroville elevations as far back as 1985, via the California Data

Exchange Center website. The website also contains Lake Oroville storage data (measured in af) covering the life of the project from 1968 to present. The Division of Operations and Maintenance website provides data on Oroville Facilities operations, including water releases, water temperatures, and river flows via SWP Operations Data Monthly Reports and SWP Annual Reports of Operations (DWR 2002). As of this writing, monthly reports were available online for January, 1990 through February, 2003, and annual reports were available for the years 1990 through 1997. Annual reports for 1998 and 1999 had not been released online, but some of the data tables were available by special request.

Water temperature data have been routinely collected at several Oroville Facilities sites in past years. Many additional data collection sites were established in the spring of 2002, primarily for the purpose of water quality studies being conducted under the direction of the Environmental Work Group (Oroville Facilities Relicensing Collaborative). Data collection has been conducted by the DWR Northern District. Data collected in 2002 and 2003 from all of these locations have been provided to the authors of this report.

4.2.3 Supplemental Survey of "Regular" Project Users

The R-3 Study Plan prescribed that researchers would "talk with local regular users to ascertain how and where facilities are affected by low pool levels and other…conditions resulting from project operations." In June, 2003 several hundred local participants in the On-Site Survey were mailed a two-page Supplemental Survey that focused on their experiences and concerns related to low pool levels and other effects of Oroville Facilities operations. The mailing list was limited to those who identified themselves as "regular" users of the area (defined within the On-Site Survey booklet as three or more visits per year), who used the area throughout the year, and who had provided a name and address on the on-site survey booklet. The Supplemental Survey used several open-ended and qualitative questions; rather than using set response choices, these recreationists were asked to answer questions in their own words (see Appendix A for the survey form used). The results of this survey, based on the 105 usable responses obtained, provide additional detail and depth to data from the primary On-Site and follow-up Mail-Back Surveys.

4.3 ASSESSMENT OF THE EFFECTS OF PROJECT OPERATIONS ON RECREATIONAL USE

The following assessment of the effects of Oroville Facilities operations on recreational use focuses on three types of facilities and related activities:

- Boat launch ramps and boat-in campsites;
- Swimming areas and swimming activity; and
- Angler use of the Feather River.

As described in Section 4.2, data to complete the assessment were drawn from three other studies conducted as part of the Oroville Facilities Relicensing process, from

existing studies, and from existing sources of data on project operations. A distinction is made in this study between assessment of effects on recreational use (i.e., the apparent usability of facilities and amount of use occurring) and assessment of effects on recreation experiences (i.e., visitors' perceptions of the effects of low water and their individual ability to use and enjoy the Oroville Facilities for recreation). This section describes the methods and data used to assess effects on visitor use; Section 4.4 describes the methods and data used to assess effects on visitors' experiences.

4.3.1 Assessment of the Effects of Low Pool Levels on Boat Access and Boat-In Campsites

Observations conducted for Study R-9 – *Existing Recreation Use*, and Study R-7 – *Reservoir Boating Survey*, provided the best information on the effects of low pool levels on boat access and boat-in campsites during the 2002 primary boating season (approximately May 15–September 15) and the beginning of the 2003 season. Field staff visited each of the five main boat ramps and the five car-top boat ramp areas on Lake Oroville several times throughout that period. The number and types of visitors using the site and the number of vehicles and boat trailers present were counted during each visit. Additional notes were taken on the apparent usability of the recreation facilities given the reservoir's elevation at that time. An evaluation of the minimum use elevations (MUE) at each boat ramp was combined with historical elevation data to characterize the historical effects of low pool levels on boat access. The MUE is the minimum Lake Oroville pool elevation required for a given boat ramp to be usable.

Field staff collecting data about boat traffic on the reservoir also made note of the presence or absence of boats at boat-in campsites. In some instances, staff members went ashore to observe the amount of boat-in campsite use. Early in the summers of 2002 and 2003, staff members also visited the boat-in campsites to survey visitors.

4.3.2 Assessment of the Effects of Low Pool Levels and Water Temperature on Swimming

Similar to assessment of effects on boating, observations conducted for Study R-9 – *Existing Recreation Use*, and visitor surveys conducted for Study R-13 – *Recreation Surveys*, provided information on the effects of low pool levels on swimming access. Survey comments related to swimming were reviewed, and several of the most representative and informative respondent comments were paraphrased for this report. Because few surveyed visitors commented on water temperatures, water temperature data were interpreted to describe likely effects of those temperatures on swimming access.

Formal swim areas within the Project area are located at the Loafer Creek DUA and the North Thermalito Forebay BR/DUA. A small beach, primarily used by PWC users and other boaters, is located at the Monument Hill BR/DUA on Thermalito Afterbay. Each of these sites provides a sand beach, picnic sites, and restrooms. The Loafer Creek swim beach is usable only at pool levels within about 50 feet of Lake Oroville's full pool

elevation of 900 feet. Because of relatively stable water levels, facilities at Thermalito Forebay and Thermalito Afterbay are usable year-round.

The 1996 California State University–Chico study named several other areas that were commonly used for informal swimming: the Spillway BR/DUA and several car-top launch locations on Lake Oroville, the South Thermalito Forebay BR/DUA, and the Larkin Road (Thermalito Afterbay) Car-Top BR.

To fully assess the effects of water temperature on swimming, it is necessary to consider water temperature data for Lake Oroville, the LFC of the Feather River below Oroville Dam, Thermalito Afterbay, and Thermalito Forebay. DWR provided data collected during 2002 in the central main basin and several arms of Lake Oroville Northern District. No data were found for sites close to the Loafer Creek swim beach and some informal swimming areas, nor for the upper arms of the reservoir. However, the relative consistency of temperatures across the reservoir surface (see Section 5.1.1.3) suggests that the data reviewed for this study provide a good indication of water temperatures in most other Lake Oroville locations. However, it is also recognized that temperatures close to areas of inflow from tributary streams could be colder than temperatures in other areas of the reservoir, particularly during the early summer when inflow is greatest. It is also assumed that some localized warming may occur in more shallow or protected coves where water circulation may not regularly occur.

The SWP Annual Reports provide daily mean water temperatures for two other locations: the Feather River Fish Hatchery (temperature of water diverted from the Thermalito Diversion Pool) and the Thermalito Afterbay outlet. Temperature data were also obtained for numerous sites in Thermalito Forebay, Thermalito Afterbay, and the Feather River where DWR has established an extensive network of water quality monitoring sites.

As described for Loafer Creek DUA, no water temperature data specific to beach areas at the North Thermalito Forebay DUA or Monument Hill (Thermalito Afterbay) BR/DUA, nor other informal swimming locations on Thermalito Forebay and Thermalito Afterbay, were found. However, data collected at sites within other areas of Forebay and Afterbay generally provide a reasonable substitute for more location-specific information.

An exception to this assumption may be the swim beach at the North Thermalito Forebay BR/DUA. The beach is situated on a shallow lagoon connected by a narrow channel to the main body of the North Thermalito Forebay. The temperature of the water entering Thermalito Forebay from the Thermalito Power Canal is known to be around 60°F, but the water in the lagoon may warm somewhat above this in the summer. To ascertain the amount of warming that may occur, DWR Northern District conducted measurements during late summer 2003 at the North Thermalito Forebay

lagoon, in addition to the routinely scheduled measurements at the established Forebay monitoring sites.

4.3.3 Assessment of the Effects of Flow Rates and Temperature on Fishing

The primary sources of information to assess the potential effects of flow rates and temperatures on fishing are fisheries studies being conducted under the direction of the Environmental Work Group (Oroville Facilities Relicensing Collaborative). Study F-3.1 – *Evaluation of Project Effects on Fish and Their Habitat Within Lake Oroville, Its Upstream Tributaries, the Thermalito Complex, and the Oroville Wildlife Area*, characterizes fish species composition and fish habitat and evaluates Project effects on fish and their habitat within Project reservoirs. Three other fisheries studies (F-3.2 – *Evaluation of Project Effects on Non-Salmonid Fish in the Feather River Downstream of the Thermalito Diversion Dam*; F-10 – *Evaluation of Project Effects on Salmonids and their Habitat in the Feather River Below the Fish Barrier Dam*; and F-16 – *Evaluation of Project Effects on In-Stream Flows and Fish Habitat*) provide similar information for the Feather River. The latter studies pay special attention to Chinook salmon and steelhead, the two most popular target species for Feather River anglers.

Information obtained by visitor surveys and observations of recreational use in the study area augments the information provided by the fisheries studies. These sources will be examined for information related to such issues as the ability of anglers to wade, and to fish from a boat, given existing Feather River flow rates and water temperatures.

4.4 ASSESSMENT OF THE EFFECTS OF PROJECT OPERATIONS ON RECREATIONAL EXPERIENCES

A generally qualitative approach to assessing Oroville Facilities operational effects on recreation experiences was developed for this report. Many comments provided by reservoir users on the On-Site Survey related to low pool levels and provided a useful source of data for this assessment. Comments which provided specific descriptions of the effects of low pool levels on boating facilities, shoreline access, and swimming access were reviewed as the most proximate source of information on the effects of Oroville Facilities operations on visitors' recreation experiences.

A limited amount of quantitative data is available from visitors who agreed to receive a follow-up Mail-Back Survey to the On-Site Survey. Those visitors were asked how problematic four specific issues related to low water levels were at the area where they were surveyed. Responses from visitors contacted at Lake Oroville sites were selected and analyzed for this section. Responses from visitors contacted along the Feather River, Thermalito Diversion Pool, Thermalito Forebay, and Thermalito Afterbay recreation sites were not included in this analysis because most water-level issues are not relevant to those recreation areas.

The Supplemental Survey effort conducted for this study (described in Section 4.2.3) provides additional input on the effects of project operations from a smaller, more targeted subset of Lake Oroville area recreationists.

4.5 ASSESSMENT OF FUTURE OPERATIONAL SCENARIOS

This assessment examines how changes in pool levels and water temperature, different release patterns from the Oroville Facilities, and other operational factors might affect recreational use in the study area. The assessments described in the preceding sections highlight effects of current operations on pool levels, water temperatures, and river flows on recreation facilities and uses.

The effects of specific future Oroville Facilities operational scenarios on recreation can be extrapolated from these observations of current effects. The potential effects of operational scenarios on key variables such as Lake Oroville elevation and Feather River flows and temperatures are a product of operations modeling conducted under the direction of the Operations and Engineering Work Group.

Finally, this assessment also uses recreation attendance models for Lake Oroville and Thermalito Forebay that incorporate Lake Oroville pool level as a factor. This model was developed during 2003 for Study R-12 – *Projected Recreation Use*.

5.0 STUDY RESULTS

This organization of section of the report is similar to that of the preceding Methodology section. The four subsections discuss (1) known issues surrounding current and historical Oroville Facilities operations; (2) effects of Oroville Facilities operations on recreational use; (3) effects of operations on recreation experiences; and (4) the potential effects of future operational scenarios on recreation.

5.1 PROJECT OPERATIONS ISSUES AND HISTORIC DATA ON OPERATIONS

At Lake Oroville, the dominant project operations issue related to recreation is fluctuation in the reservoir pool level resulting from annual drawdown of stored water. At Thermalito Diversion Pool, Thermalito Forebay, and Thermalito Afterbay, the effects of operations on recreation relate more to low water temperatures than to pool elevation. On the Feather River below the Diversion Dam, the effects of Oroville Facilities operations on flow rates and temperatures are of most interest. The effect of some aspects of Project operations on water temperature in the channels and reservoirs downstream of Oroville Dam are complicated by the conflicting temperature needs of agricultural and fishery uses of the water.

Field data collection and observations conducted for other recreation studies, as well as informal observations that occurred throughout the 2002 and early 2003 recreation seasons, have provided information on specific recreation facilities affected by Oroville Facilities operations. In addition, data from the 2002 and earlier recreation seasons on pool elevation, water temperature, water inflow and outflow, and other operational records have been compiled and reviewed. Specific observations of the effects of Oroville Facilities operations on access to and use of facilities are discussed in detail in Section 5.2 below.

5.1.1 Lake Oroville Issues and Historical Operations

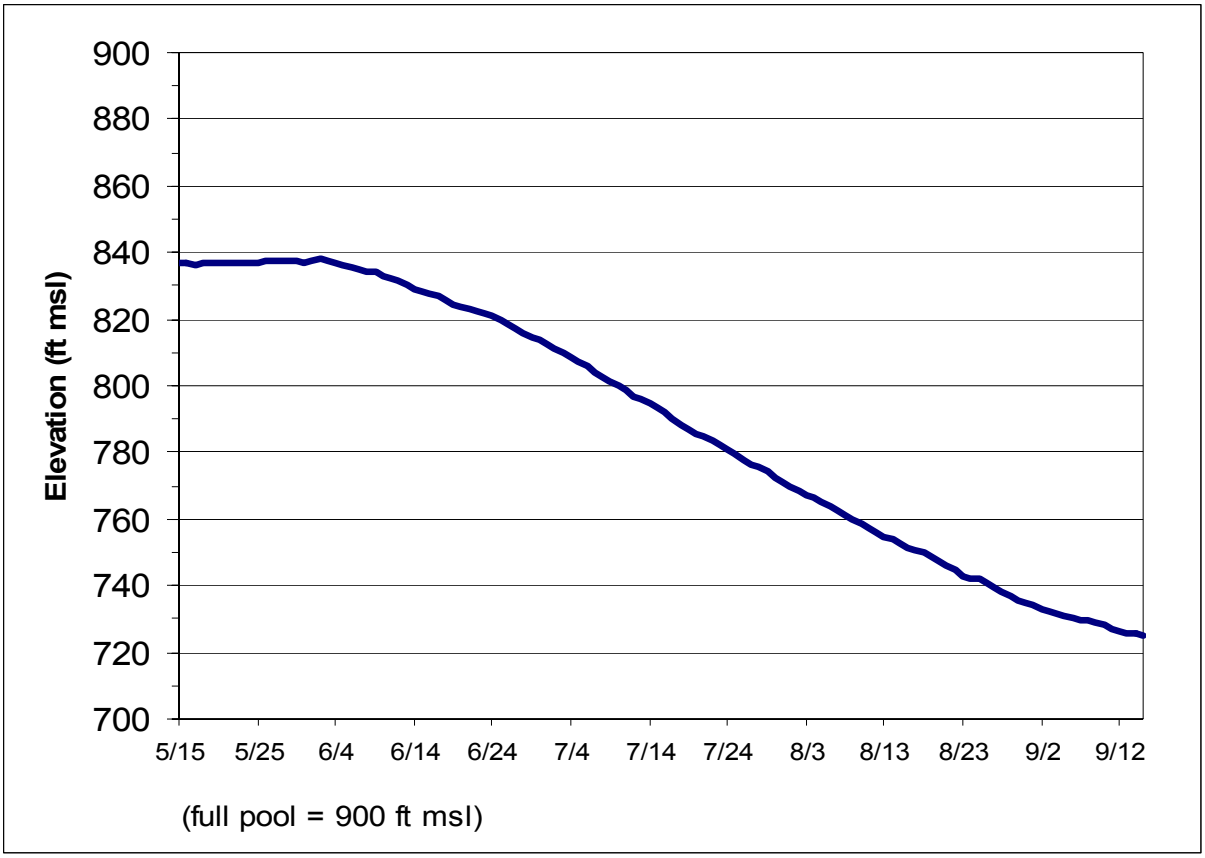
The effects of operations on Lake Oroville recreation activities and facilities relate primarily to the low elevation of the water beginning in mid- to late-summer or early-fall in most years. Consequently, most of the information presented in this section relates to pool levels. Because water contact recreation is an important component of public use and because Lake Oroville is the source of the water in the downstream portions of the project, water temperature information is also provided.

5.1.1.1 Lake Oroville Pool Elevation During 2002 Summer Recreation Season

The majority of the boating and other recreation observations made at Lake Oroville for all of the recreation studies were made during the 2002 summer recreation season. Lake Oroville elevation during that period ranged from about 837 feet above msl in mid-May to 725 feet above msl in mid-September, a range of about 112 feet (Figure 5.1-1). (All pool elevations stated from this point forward for Lake Oroville, Thermalito Forebay, and Thermalito Afterbay are elevations above msl.) Pool elevation held steady through May, then fell slightly more than one foot per day, on average,

through June, July, and August. Appendix B provides daily Lake Oroville elevation data for the entire May, 2002 to May, 2003 field data collection period.

Figure 5.1-1. Lake Oroville daily elevation, May 15–September 15, 2002.



Source: DWR 2003a.

5.1.1.2 Historic Lake Oroville Pool Elevations

Lake Oroville elevations throughout the year and during the primary recreation months from May to September in particular have varied widely since the reservoir was first filled in 1968. The typical annual pattern is for the reservoir to fill through the late winter and spring until it reaches a maximum elevation for the year in May or June. The reservoir will then drop 6–12 inches per day, on the average, throughout the summer and fall seasons until it reaches a minimum elevation in December or January. Factors such as winter snowpack and winter and spring rainfall in the watershed, downstream water demands, and environmental requirements affect how high the reservoir rises by the start of the season in May and how low it drops, and at what rate, through the rest of the year.

Daily reservoir elevation data have been obtained for most of the period from 1985 to the present. Monthly acre-feet storage data, from which monthly reservoir elevation can be derived, have been obtained for the entire 33-year history of the reservoir.

Examination of the elevation data focused on the 13 years from 1990 to 2002 (Table 5.1-1). The data for this period highlight the variability in reservoir elevation from year to year, in particular during the primary boating season. The period includes water years classified as "wet years" (e.g., 1995–96), "average years" (e.g., 1993–94), and "dry years" (e.g., 1991–92). Appendix C describes the water year classification system. Daily pool elevation data for 1985–89 were not used for this characterization due to large data gaps. Figures 5.1-2 and 5.1-3 illustrate the range of pool levels during the peak recreation season and annually across the 13 years.

Elevations at the end of May (just after Memorial Day weekend, which is the traditional start of the peak recreation season) ranged from a low of 751 feet in 1991 to a high of 899 feet (near-full) in 1993. The reservoir was also within a few feet of full pool at the end of May in 1995, 1996, and 1999. (In some years, the reservoir reached its high elevation for the year before the end of May, while in others the high elevation was not reached until mid- or late June.) Elevation at the end of August (near the beginning of the Labor Day holiday weekend, after which recreational activity often decreases) varied from a low of 691 feet in 1990 to a high of 877 feet in 1995. The end-of-May to end-of-August drawdown total since 1990 has usually ranged from about 50 to 75 feet. However, the drawdown was less than 20 feet in 1995 and 1998, and was over 100 feet during 2002.

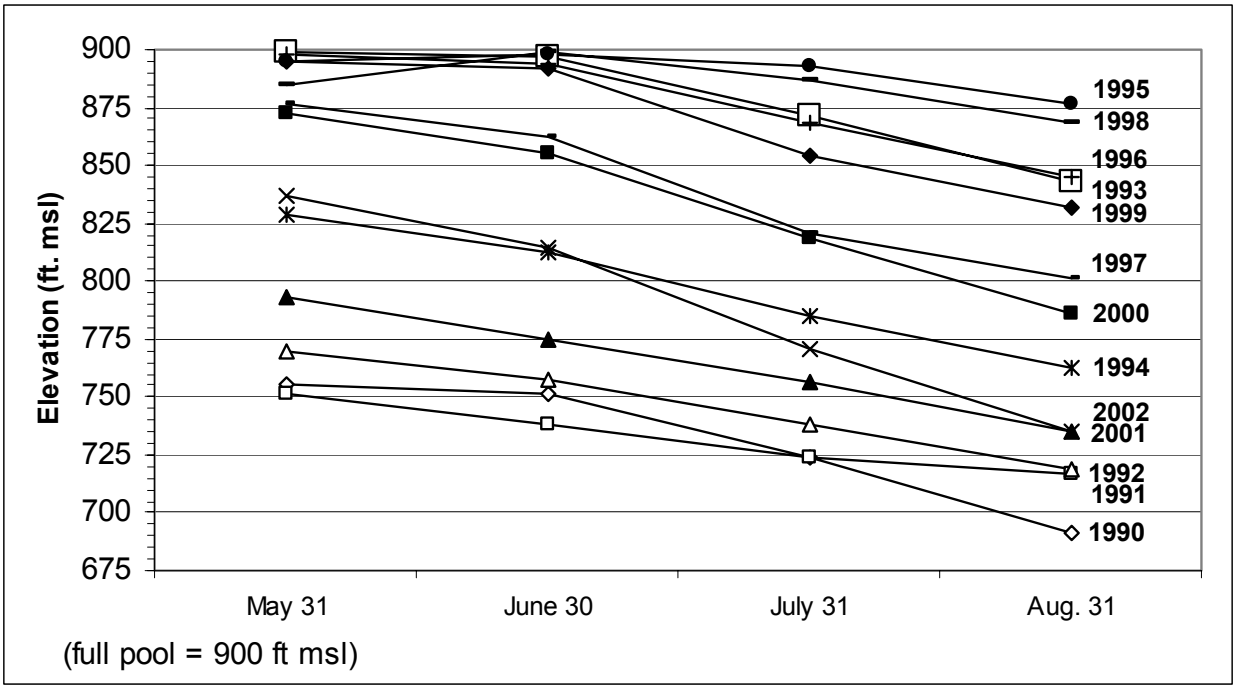
The total drawdown for these years was as little as 62 feet (1996) and as much as 178 feet (1993), a variation of 116 feet. The average annual change in elevation over the 13 years was 112 feet (standard deviation = 32 feet). Effects of low water levels on recreational facilities and activities and effects on visitor experiences would also be expected to vary significantly between these years.

Table 5.1-1. Lake Oroville historical pool elevation (ft. msl), 1990–2002.

Year	End of May Elevation	End of June Elevation	End of July Elevation	End of Aug. Elevation	Low Elevation for Year	High Elevation for Year	Date of Highest Elevation	Change in Elevation for Year
1990	755	751	724	691	663	792	March 28	129
1991	751	738	724	717	651	752	June 2	100
1992	770	757	738	719	701	785	May 3	84
1993	899	897	872	843	721	899	June 7	178
1994	829	812	785	763	735	839	April 11	103
1995	895	898	893	877	749	900	June 24	151
1996	898	894	868	845	837	900	May 22	62
1997	877	862	821	801	783	881	May 11[1]	99
1998	885	899	887	868	804	899	June 28	96
1999	895	892	854	832	800	896	June 13	97
2000	873	855	819	786	755	873	May 29	118
2001	793	775	756	735	714	801	May 7	87
2002	837	814	771	735	690	839	April 30	148
Mean	**843**	**834**	**809**	**785**	**739**	**850**	**-----**	**112**
SD[2]	**57.5**	**62.5**	**62.7**	**63.3**	**52.6**	**56.4**	**------**	**32.0**

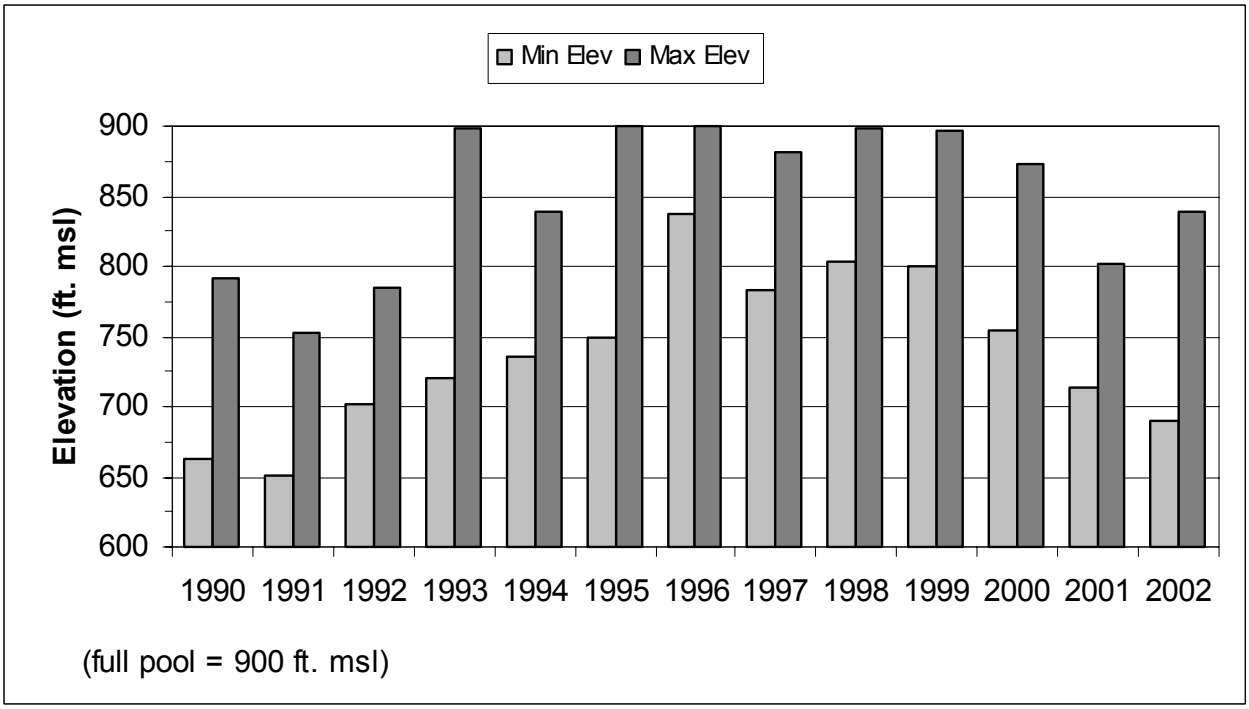
Notes:
[1] The reservoir reached an elevation of 887 ft. msl on January 2, 1997, during a major flood event. However, the elevation was lowered to 840 feet over the next 10–12 days to meet flood control requirements and later continued a more typical spring rise to the 881-foot elevation recorded on May 11, 1997. May 11 is a more meaningful date for the annual peak elevation and is used to represent the annual maximum for 1997, rather than the higher elevation resulting from the rare flood event.
[2] SD = Standard Deviation, an indicator of the variation in the data; about 68 percent of the elevations for the 13-year period on the specified dates would fall within +/- one standard deviation from the mean and about 95 percent of the elevations would fall within +/- two standard deviations from the mean.
Source: DWR 2003a.

Figure 5.1-2. Lake Oroville end-of-month pool elevations, May–Aug. 1990–2002.



Source: DWR 2003a.

Figure 5.1-3. Lake Oroville yearly high and low elevations, 1990–2002.



Source: DWR 2003a.

5.1.1.3 Lake Oroville Water Temperatures

Lake Oroville surface water temperatures during the May–September recreation season are of great interest for this study. Surface water temperatures would be expected to have a significant effect on the attractiveness of swimming and other water-contact recreation (e.g., wading, PWC use, water skiing and wakeboarding, small boat sailing).

Table 5.1-2 reports Lake Oroville surface water temperatures at four locations as measured during the primary summer recreation season of 2002. Figure 5.1-4 depicts the four locations, which were chosen among many sampling sites to represent conditions on the main basin and major arms of the lake. As expected, temperatures generally increased through the summer: from the mid-60s (°F) in mid- to late-May, to a more comfortable mid-70s (°F) in mid- to late-June, to a warm 80°F or more in mid- to late-July and August. There appears to be little variation in temperature across the main segments of the reservoir; with the exception of the Middle Fork temperature measured in May, water temperatures were within 1–2°F of each other at the four locations each month. Surface temperatures at other locations close to tributary inflows (i.e., toward the upstream end of the reservoir arms) might be expected to be colder.

The water temperature data reported in Table 5.1-2 are from "temperature profile" data collection points, where measurements were taken at 1-meter intervals from the surface to the bottom of the reservoir. Review of these data established that the temperature at the 1- and 2-meter depths was usually identical to or within a few degrees of the surface temperature. Most body-contact recreation, such as swimming and water skiing, results in exposure to the water only at and within 1 or 2 meters of the surface. Therefore, the near-surface temperatures reported in Table 5.1-2 can be considered a good representation of the water temperature that swimmers, water skiers, and others would experience.

Table 5.1-2. Lake Oroville surface water temperature, 2002 recreation season.

Monitoring Location	Temperature (°F)			
	May 2002	June 2002	July 2002	Aug. 2002
Lake Oroville—Main Basin	67	76	80	80
Lake Oroville—Middle Fork	73	78	82	79
Lake Oroville—South Fork	65	78	82	81
Lake Oroville—North Fork	64	77	81	81

Note: Measurements were taken during the third and fourth weeks of each month, within a 7-day period of each other. All were taken slightly below the surface (0.15 meter). See Figure 5.1-4 for monitoring locations.
Source: DWR (Northern District) 2003.

Figure 5.1-4. Lake Oroville water temperature sampling sites.

[8x11 insert]

5.1.1.4 Reservoir Level Effects on Shoreline Recreation Facilities and Use

Given the popularity of boating at Lake Oroville, the effect of reservoir levels on the ability of visitors to launch boats is a primary focus of this assessment. During 2002, note was made of dates on which Lake Oroville boat launches became unusable and the corresponding reservoir elevation on those dates. Three of the four major boat ramps were extended by DWR in late 2002. Observers also noted the effects of reservoir drawdown on the function and convenience of the ramps for boaters.

Observations of reservoir level effects were also made at Lake Oroville Car-Top BRs and BICs. The car-top boat ramps are used by moderate numbers of boaters and non-boating shoreline recreationists. The BICs provide most of the land-based camping on Lake Oroville with close access to the water from the campsites, since the campgrounds at Loafer Creek and Lime Saddle are some distance from the shoreline. (The Bidwell Canyon campground provides some shoreline access to campers, but the area is dominated by the Bidwell Marina.)

Swimming and wading from shore (as opposed to from a boat) is also an important activity for many Lake Oroville visitors. Therefore, observations were made of the effect of reservoir elevation on swimming access at the developed swim area within the Loafer Creek recreation area and other undeveloped locations on the reservoir used for swimming and other shoreline recreation such as bank fishing and picnicking.

The specific effects of low reservoir levels on each of these types of facilities and recreation activities, as observed during 2002 and 2003 and as indicated by historical operations data, are discussed in detail in Section 5.2 of this report.

5.1.2 Thermalito Diversion Pool, Thermalito Forebay, and Thermalito Afterbay Observations and Issues

Because pool elevations are relatively stable at Thermalito Diversion Pool and Thermalito Forebay, the primary operation issue of interest is water temperature. At Thermalito Afterbay, pool elevation is more variable, so both elevation and water temperature were studied.

Elevation changes at Thermalito Forebay are less than at Thermalito Afterbay because the only major outflow from Thermalito Forebay is through the Thermalito Pumping-Generating Plant, and this outflow is usually about equal to or slightly less than the inflow (from Lake Oroville releases, passing through the Thermalito Diversion Pool and the Thermalito Power Canal). Thermalito Forebay and Thermalito Afterbay are linked by the tail channel that carries water from Thermalito Forebay to Thermalito Afterbay after passing through the Thermalito Pumping-Generating Plant. On several days during each summer recreation season, the Thermalito Pumping-Generating Plant pumps water back into Thermalito Forebay from Thermalito Afterbay. Pumpback occurred on 37 days between May 15 and September 15, 2001 and 8 days during that

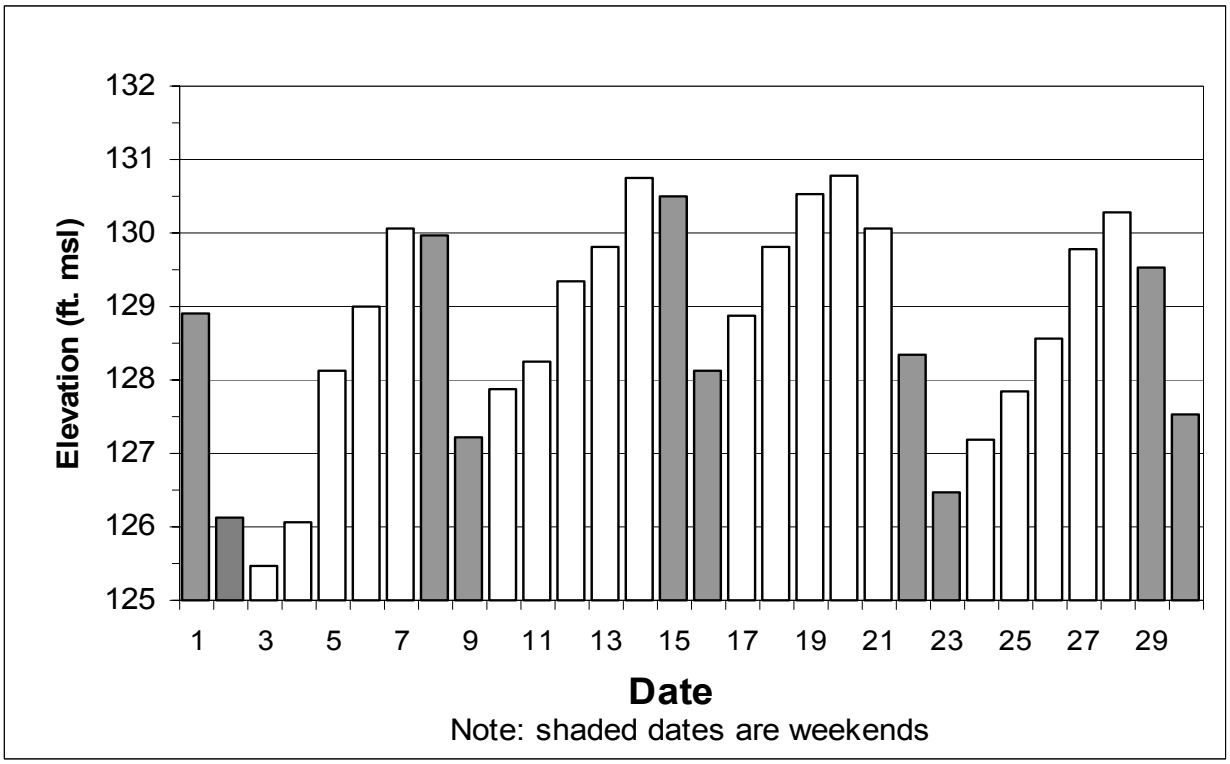
period in 2002. Water is released from Thermalito Afterbay into four irrigation canals and to the Feather River.

5.1.2.1 Thermalito Diversion Pool, Thermalito Forebay, and Thermalito Afterbay Elevation

No data are readily available on the daily elevation of Thermalito Forebay or the Thermalito Diversion Pool. However, storage data reported in the DWR *State Water Project Operations Data* monthly reports (DWR 2002) for the Thermalito Diversion Pool and Thermalito Forebay indicate that storage (and thus elevation) changed only slightly from day to day during the 2002 recreation season.

Overall, surface elevation fluctuates much less at Thermalito Afterbay than at Lake Oroville. During the 2002 summer recreation season, the elevation of Thermalito Afterbay fluctuated from approximately 125 to 132 feet above msl. However, the elevation can change quickly—as much as 3 or 4 feet in 24 hours. The changes in elevation follow a weekly cycle dictated by hydropower operations and can be generally characterized by a gradual increase in elevation from Monday through Friday followed by a more rapid decrease in elevation during the weekend. Figure 5.1-5 illustrates the typical weekly pattern with data from June, 2002.

Figure 5.1-5. Thermalito Afterbay daily mean elevations, June 2002.



Source: DWR 2003a.

The typical 24-hour elevation gain is about 6 inches to 1 foot; the typical 24-hour elevation loss is 1.5–3 feet. These changes have occasionally resulted in stranded boats, if they are moored too long in shallow areas (pers. comm., Rischbieter 2003). As reported in Study R-2 – *Recreation Safety Assessment*, the Butte County Sheriff's Office and DFG have stated that boating accidents and damage to boat motors have occurred in areas that had become very shallow overnight due to the rapid drawdown of Thermalito Afterbay.

5.1.2.2 Thermalito Diversion Pool and Thermalito Forebay Water Temperatures

Little water-contact recreation occurs at the Thermalito Diversion Pool. A discussion of water temperature there is included in this report primarily because that is the starting point, physically and in terms of temperature, for the water that flows from there to downstream sites where water contact recreation does commonly occur. As was the case for Lake Oroville, emphasis is placed on surface or near-surface temperatures since this is where most water-contact recreation occurs.

The water released into the Thermalito Diversion Pool from Lake Oroville, primarily through the Hyatt Pumping-Generating Plant, is drawn from the reservoir's hypolimnion[1] (cold, deepwater layer) generally at a temperature of about 45°F. During the summer, the water warms by 10–15°F by the time it reaches Thermalito Diversion Dam, 4 miles downstream. The mean daily water temperature at Thermalito Diversion Dam ranged from 52 to 60°F during the 2002 recreation season (Table 5.1-3). The maximum temperature was 59°F among the four days for which data were available for all three Thermalito Diversion Pool and Forebay sites. (The data was collected on a limited number of sampling dates as part of water quality studies conducted under the direction of the Environmental Work Group.)

Table 5.1-3. Thermalito Diversion Pool and Thermalito Forebay surface water temperature, 2002 recreation season.

Sampling Sites	Temperature (°F)			
	May 22	June 17	July 18	August 19
Thermalito Diversion Dam[1]	52	59	57	57
North Thermalito Forebay[2]	53	59	58	57
South Thermalito Forebay[3]	54	61	58	60

[1] Mean temperature of water diverted to the Feather River Fish Hatchery from Thermalito Diversion Pool at Thermalito Diversion Dam.
[2] Temperature just below the surface (0.15 meter) at a water quality profile station located a short distance upstream of the Nelson Road bridge that separates the North and South Forebay.
[3] Temperature just below the surface (0.15 meter) at a water quality profile station located near the middle of the South Forebay.
Sources: DWR 2002 (Diversion Dam); DWR (Northern District) 2003 (North and South Thermalito Forebay).

[1] The layer of water in a thermally stratified lake that lies at deeper levels, is non-circulating, and remains perpetually cold.

The water diverted at Thermalito Diversion Dam is carried about 2 miles west in the Thermalito Power Canal, to the northeast portion of Thermalito Forebay. This inlet is immediately to the south and on the other side of a peninsula from the lagoon where the North Forebay BR/DUA and swim beach are located. The data indicate that the water warms only very slightly, if at all, by the time it reaches the west end of the North Forebay, and warms by just 1–2°F more in the South Forebay. Figure 5.1-6 depicts the Diversion Pool and Thermalito Forebay water temperature data collection locations.

There is no permanent water quality monitoring station in the North Forebay lagoon containing the swim beach. However, temperature data were collected from the lagoon on two occasions during the late summer of 2003. The purpose of these measurements was to determine whether the reduced water circulation and relative shallowness (about 6 feet maximum depth) of the lagoon would allow the water to warm appreciably. The data indicate that the surface water warms by 15°F or more as compared to the main body of the North Forebay; the maximum temperature measured was 74°F. However, temperatures measured at 1 meter and 2 meters below the surface were in the low 60s, only a few degrees warmer than the main body of the Forebay.

5.1.2.3 Thermalito Afterbay Water Temperatures

For reasons described earlier, water temperature data reported here are focused on surface or near-surface temperatures. Water enters Thermalito Afterbay from Thermalito Forebay via the tail channel of the Thermalito Pumping-Generating Plant, at the northeast end of Thermalito Afterbay. (The flow is reversed during occasional pump-back operations.) Water temperature data collected near the terminus of the channel (near the Wilbur Road BR) indicate that the water is about the same temperature at that point as in South Thermalito Forebay where it originated (Table 5.1-4). Figure 5.1-7 depicts Thermalito Afterbay water temperature data collection locations.

Table 5.1-4. Thermalito Afterbay surface water temperature, 2002 recreation season.

Sampling Sites	Temperature (°F)				
	May 9	June 6	July 2	July 31	Aug. 29
Wilbur Road BR[1]	52	55	59	57	59
South Afterbay Profile Station [2]	NA	68	64	63	64
South Afterbay (Transect B, Station 1)[2]	58	64	NA	NA	63[3]
Afterbay Outlet (Transect D, Station 10)[2]	62	72	NA	NA	67

[1] Data are from a water temperature data logger at 1 meter below the surface, located near the end of the tailrace channel and the Wilbur Road BR.
[2] Temperature of water measured at the surface.
[3] Date of measurement was September 3, 2002, which was 5 days after other sites.
Source: DWR (Northern District) 2003.

Figure 5.1-6. Diversion Pool and Thermalito Forebay water temperature data collection locations.

[8x11 insert]

Figure 5.1-7. Thermalito Afterbay water temperature data collection locations.

[8x11 insert]

The Monument Hill area, with its small but popular beach, is the primary site where swimming and wading occurs in the Afterbay. The beach is about 1 mile to the southwest of the tail channel outlet, but is separated from it by a large peninsula. Although no data are available specifically for the Monument Hill beach, data were collected by DWR once or twice per month at two nearby sites (as part of the monitoring that occurred within a network of water quality sampling locations). The first site is a water quality profile station located about 1800 feet west of the beach, out in the main body of the South Afterbay. The second site is the easternmost station in a transect line (Transect B, Station 1) reaching across Thermalito Afterbay. This site is located 45–90 feet from the Monument Hill area, depending on the pool elevation at the time of measurement, at the mouth of the Monument Hill cove.

The data collected on the one date (June 6, 2002) for which data are available for both locations (Table 5.1-4) suggests that the water temperature may be a few degrees warmer in the main body of Thermalito Afterbay than in the Monument Hill cove, closer to the beach. However, these limited data are insufficient to establish whether this is typical. Overall, the data suggest that the water temperature at the Monument Hill beach was in the low or mid-60s throughout the summer of 2002.

The water temperature data for the station nearest the Thermalito Afterbay outlet, where water from the Thermalito Complex returns to the Feather River, suggest that the water is 3–5°F warmer than near Monument Hill about 3 miles away. Along with the area near Monument Hill, the portion of Thermalito Afterbay near the Larkin Road Car-Top BR, immediately to the north of the outlet, is commonly used by PWC riders. PWC use, along with swimming and wading, is the other common form of water-contact recreation occurring on Thermalito Afterbay.

Reviewing the entire Thermalito Complex (between the Thermalito Diversion Pool and the Thermalito Afterbay outlet), the data during most of the summer recreation season indicate that the water warms by perhaps 10–13°F as it passes through the system, although areas sheltered from circulation may exhibit additional localized warming.

5.1.2.4 Swimming-Related Observations and Issues

Shoreline swimming occurs at two primary sites in the Thermalito area: at the swim beach within the North Thermalito Forebay BR/DUA and at the smaller beach used primarily by PWC user groups adjacent to the Monument Hill boat ramp. Visitor use observations conducted at both of these sites indicate that both are very popular and are the most heavily used shoreline recreation sites in the area. A small amount of swimming also occurs at the South Thermalito Forebay BR/DUA and at Larkin Road Car-Top BR/DUA (Thermalito Afterbay). Other water-contact recreation such as water skiing, wakeboarding, and PWC use occurs on the south half of Thermalito Forebay (power boats are prohibited on the north half) and in all areas of Thermalito Afterbay.

Because of the small amount of pool level fluctuation in Thermalito Forebay and Thermalito Afterbay, the boat launch, day use, and swimming facilities on those reservoirs are affected only slightly by changes in water level and are usable throughout the year. However, the water flowing through Thermalito Forebay and Thermalito Afterbay is released from Lake Oroville at a temperature usually below 50 degrees. Some warming of the water occurs as it travels through the Thermalito Diversion Pool, Thermalito Forebay, and Thermalito Afterbay, but the available data indicate that the temperature remains below what is considered a comfortable range for body-contact water recreation. (Most available standards for water temperature in rivers and lakes are maximum temperatures based on coldwater and warmwater fishery requirements. No temperature standards for water-contact recreation in natural water bodies have been found.) The water temperature in Thermalito Afterbay is managed to meet a 1969 agreement with local agricultural water users, as detailed in Section 1.4.1.2.

5.1.3 Feather River Observations and Issues

The primary project operations issues of interest for the Feather River below Thermalito Diversion Dam are the amount and temperature of flows passing down the river. These have a critical influence on the fishery in the river, and thus on angling opportunities. They also can potentially affect other forms of river recreation like swimming and motorized and non-motorized boating.

5.1.3.1 Water Temperatures in the Feather River

Daily water temperature data are available for more than 15 locations in the Feather River downstream of the Thermalito Diversion Dam and within the study area. Table 5.1-5 provides the maximum water temperature for five river locations on the last day of each of the four months in the primary summer primary recreation season in 2002. Figure 5.1-8 depicts the five water temperature sampling sites on the Feather River. The data indicate that the water entering the Feather River below the diversion dam remained below 60°F throughout the summer. Review of daily temperature data for that location revealed that the mean daily temperature was very steady, generally not changing more than a degree or two from one day to the next. The temperature was 55–60°F nearly every day of the June–August period.

Table 5.1-5. Maximum water temperatures in the Feather River downstream of the Thermalito Diversion Pool, 2002 recreation season.

Sampling Site (approx. river mile)	Temperature (°F)			
	May 31	June 30	July 31	August 31
Feather River downstream of Diversion Dam (RM 68)	54	58	57	54
Feather River at Auditorium Riffle (RM 66.5)	56	60	58	55
Feather River at Robinson Riffle (RM 61.5)	63	67	64	59
Feather River upstream of Afterbay outlet (RM 59)	64	67	65	61
Feather River near One-Mile Pond (RM 57.5)	72	68	67	67

Note: RM = river mile.
Source: DWR (Oroville Field Division) 2003.

Figure 5.1-8. Feather River water temperature data collection locations.

The river warms by only 1–2°F by the time it reaches Auditorium Riffle, about 1.5 miles downstream near downtown Oroville. However, the river averaged about 6°F warmer at Robinson Riffle, about 5 miles farther downstream. No data are available for river locations nearer to Riverbend Park, the major public access to the river between Auditorium Riffle and Robinson Riffle. However, the available data suggest that the river in that area would have maximum daily summer temperatures in the low 60s (°F).

The highest water temperature measured on all four days was at the river site near One-Mile Pond (about 1.5 miles downstream of the Thermalito Afterbay outlet). This was the case because the greater downstream distance allowed more solar and ambient warming, and because the typically much-greater volume of water released from Thermalito Afterbay is sometimes warmer than the water in the LFC at that location (Figure 5.1-8). Seasonally, the maximum daily temperature was greatest at the end of June at the four LFC locations (upstream of the Thermalito Afterbay outlet). Temperatures fell by 1–5°F at those locations in July and August.

The impoundment of the Feather River by Oroville Dam has resulted in a decrease of the maximum annual water temperature, as measured just below the Diversion Dam. Prior to impoundment, the maximum water temperatures in the river at that location typically ranged from 70 to 75°F, and on rare occasions reached temperatures just over 80°F (DWR 2001).

5.1.3.2 Flow Rates for the Upper and Lower Reaches of the Feather River

As described above, the Feather River in the study area consists of two sections. The LFC (upper reach) carries water passed through the Thermalito Diversion Dam Generating Plant and over the Fish Barrier Dam and extends about 10 miles from the Fish Barrier Dam to the point where the Thermalito Afterbay outlet empties into the Feather River. The lower reach begins at the Thermalito Afterbay outlet, where water released from Thermalito Afterbay greatly contributes to flow in the Feather River channel; the study area extends about four miles downstream from this point.

Review of daily operational data for May–August 2002 indicates that 93–97 percent of the water released from Lake Oroville was diverted to Thermalito Forebay and through the Thermalito Pumping-Generating Plant. Most of the remaining 3–7 percent of the water was released to the LFC. Releases to the LFC were consistently held to a mean flow rate of about 600 cfs[2], the minimum required, through nearly all of May and June 2002. Releases to the LFC were about 700 cfs most days in July and August 2002, with the exception of a few 1- to 3-day periods when releases were increased by 50-150 cfs. During one 3-day release event intended to benefit the LFC fishery and

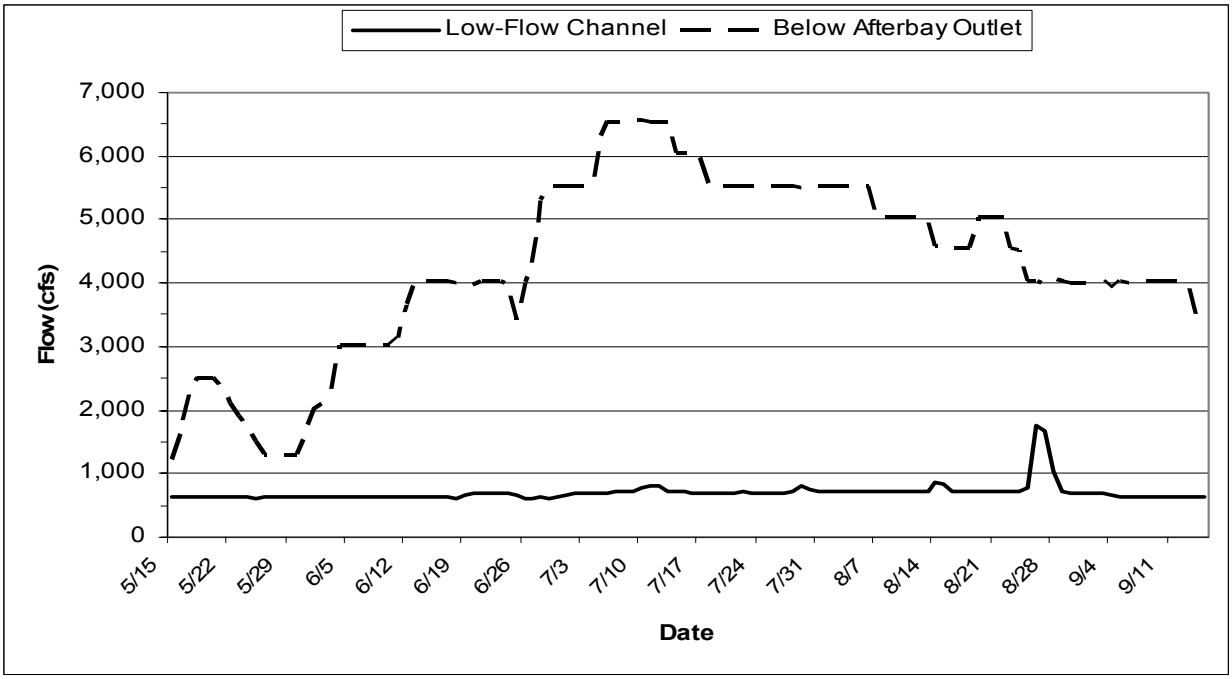
[2] Oroville Facilities operational data related to flow, obtained from DWR-published sources (DWR 2002), are stated in acre-feet per day (af/day). One acre-foot (af) is the volume of water that would cover 1 acre 1 foot deep (equal to 43,560 cubic feet or 325,851 gallons). Acre-feet per day figures were converted to the more common cubic feet per second (cfs) unit of measurement by multiplying by 0.504. Thus, 2,000 af/day of flow equals a mean flow for that day of about 1,000 cfs.

conducted for studies under the purview of the Environmental Work Group, 1,000–1,750 cfs were released.

The 2002 daily operational data indicate that flows in the lower reach, unlike in the LFC, varied greatly over the May–September period. Throughout most of May, flow from the Thermalito Afterbay outlet was about equal to the LFC flow, resulting in a steady flow below the Thermalito Afterbay outlet of about 1,200 cfs. For about a 10-day period in May, flow from Thermalito Afterbay was temporarily increased such that flow below the outlet was as high as 2,500 cfs. Through most of the remaining summer months, daily flows from the Thermalito Afterbay outlet were from four to eight times the flow in the LFC. The flow increased in stages through June and until mid-July, when flow below the outlet was held at the seasonal high of approximately 6,500 cfs for an 8-day period. The flow was held at about 5,500 cfs from mid-July through the first week of August, and then was reduced to 4,000–5,000 cfs for the remainder of the month.

Figure 5.1-9 provides a graphic representation of Feather River daily flows, both in the LFC and the high-flow section below the Thermalito Afterbay outlet, during the 2002 summer recreation season. The solid line represents the flow of the LFC. The dashed line represents the flow in the high-flow section of the river resulting from the combined flows of the LFC and the water released from the Thermalito Afterbay outlet.

Figure 5.1-9. Flows in the Feather River low-flow and high-flow sections, May 15-September 15, 2002.



Source: DWR 2002.

The change in height of the dashed line highlights the effect of the large changes in flow from the Thermalito Afterbay outlet on flows in the lower section of the Feather River. The relatively steady flow rate of the LFC and the stepwise increases in flow in the high-flow channel with a mid-July peak period are evident.

5.2 EFFECTS OF PROJECT OPERATIONS ON RECREATIONAL USE

This section provides a brief historical perspective on pool levels in Lake Oroville and attendance at several types of recreation facilities since 1990. The intent is to preliminarily assess whether any consistent, long-term relationship exists between pool levels and overall use of the recreation facilities. Statistical modeling of the effect of reservoir drawdown on visitation is contained in Study R-12 – *Projected Recreation Use*.

The remainder of the discussion of operational effects of the Oroville Facilities on recreational use will focus on several types of facilities most directly affected by changes in pool elevation. Additional discussion addresses effects of water temperature on swimming activity and of flow rates and temperature below Lake Oroville on fishing activity.

5.2.1 Effects of Low Pool Levels on Overall Recreational Use of Lake Oroville

Attendance and Lake Oroville pool level data from 1990 to 2001 were compared to assess the relationship between pool levels and recreational uses and to provide a historical perspective about how project operations affect recreational uses. Project operations affect water flows and temperatures as well as pool levels throughout the Project area, but only pool levels in Lake Oroville vary substantially from year to year. Historic attendance data (reported by fiscal year) are available for Lake Oroville, but it is generally not possible to relate these data to specific types of recreation. Thus, the focus of this analysis is on Lake Oroville pool levels and overall recreation attendance at the reservoir. (Appendix B of Study Report R-12 – *Projected Recreation Use* provides additional detail on attendance data.)

Table 5.2-1 provides a direct comparison of attendance and pool elevation across the 11 years by ranking each year on the two factors and placing the ranks side by side. This comparison suggests that Lake Oroville attendance and pool elevation are related to some degree, as expected; the years in which pool elevation was low also tended to have lower attendance, and the years in which pool level was higher tended to have higher attendance (i.e., there is a positive relationship). For example, fiscal year 1995-96 is ranked first among the 11 years both in average pool elevation and attendance. Conversely, the lowest attendance during the 11-year period was during fiscal year 1991-92, the year with the second lowest average pool elevation.

However, this analysis suggests that other factors also influence attendance. That is, the relationship between pool level and attendance may be moderated by economic changes, weather, availability of similar recreation opportunities elsewhere in the region,

and many other factors unrelated to Oroville Facilities operations. Several such potential explanatory variables were evaluated, along with pool elevation, as part of recreation visitation model development for Study R-12 – *Projected Recreation Use*. That modeling effort did establish that low pool levels in Lake Oroville negatively affect recreation attendance at the reservoir. Specifically, the model results provide an estimate that a 1 percent increase in the average reservoir level (e.g., from 800 feet to 808 feet) during the July–June fiscal year would result in an increase of 13,084 visitors during that year, holding all other factors constant. (Study R-12 – *Projected Recreation Use* provides a full description of the models developed and the variables evaluated. It also provides more specific description and quantification of the effect of reservoir drawdown and other factors on attendance.)

Table 5.2-1. Lake Oroville attendance and average pool elevation, fiscal years 1990-91 to 2000-01.

Fiscal Year (July 1-June 30)	Attendance[1]	Attendance Rank	Average Monthly Pool Elevation (ft. msl)[2]	Elevation Rank
1990–91	463,718	9	699.9	11
1991–92	364,653	11	731.7	10
1992–93	520,505	6	781.2	8
1993–94	578,379	4	837.4	4
1994–95	638,496	2	807.3	7
1995–96	696,140	1	868.2	1
1996–97	626,561	3	856.0	3
1997–98	416,854	10	830.0	6
1998–99	464,724	7	864.3	2
1999–2000	464,326	8	837.3	5
2000–01	572,627	5	780.8	9

[1] Attendance figures include only Lake Oroville sites; recreation areas within LOSRA but not on Lake Oroville (Thermalito Diversion Pool and Thermalito Forebay sites) are excluded.
[2] Elevation figures are based on monthly average pool elevations for the 12 months in each fiscal year.
Sources: DWR 2003b (Attendance); DWR 2003a (Pool elevation).

Although the general negative effect of low pool levels has been established, the data summarized in Table 5-2.1 further indicate that a high average pool level in a given year may not result in high attendance, and relatively low pool levels may not always lead to low attendance. A case in point is fiscal year 1998-99: The attendance of about 465,000 was just the seventh highest among the 11 years, although the average pool elevation was nearly the highest of the 11 years. The difference in average pool elevation compared to the highest elevation year was just 4 feet, but attendance was more than 230,000 less. The opposite situation is illustrated by the 1994-95 fiscal year, when attendance was more than 170,000 *higher* than the previous example (1998-99) although the average pool elevation was nearly 60 feet *lower*. Stated in terms of ranks,

the second-highest attendance of the 11-year period occurred during the year with the seventh-highest average pool elevation.

Although this simple analysis is not intended to examine trends, it can be speculated that for both of the above cases a "carry-over" effect related to water levels during the preceding year or years may have resulted in higher or lower attendance than might be expected based on that year's average monthly pool elevation. That is, a single high or low water level year or a succession of relatively high or low water level years may continue to affect attendance after water levels have changed.

5.2.2 Effects of Low Pool Levels on Boat Ramp Access

The five primary boat ramps at Lake Oroville and their general locations are as follows:

- Spillway BR (southwest corner of main basin, near the dam);
- Lime Saddle BR (west side of West Branch);
- Loafer Creek BR (east side of Bidwell Canyon, south of main basin);
- Bidwell Canyon BR (west side of Bidwell Canyon, south of main basin); and
- Enterprise BR (north side of South Fork arm).

5.2.2.1 Effects of Low Water on Lake Oroville Boat Ramp Usability During 2002

The boat ramps at Lime Saddle, Bidwell Canyon, and Spillway Recreation Area remained usable throughout the prime recreation season of Memorial Day to Labor Day in 2002. Each ramp became unusable at some point in the fall, but temporary extensions were put in place by California Department of Parks and Recreation (DPR) to facilitate their use for bass fishing tournaments. Permanent extensions were subsequently completed at the three ramps when the reservoir was at its lowest elevation in November and early December, 2002. The effect of these extensions on launch ramp usability is discussed in Section 5.2.2.3. The reservoir reached its low elevation for the year on December 12, at about 690 feet.

The Spillway launch facilities provide the best boat access during periods of low water. The 12-lane upper Spillway launch ramp was unusable by early July 2002. However, the eight-lane paved low-water ramp, directly below the upper ramp, allowed continued launching until mid-September, 2002. The ramp complex includes floating docks and several hundred paved car/trailer parking spaces. A temporary unpaved extension of the low-water ramp made the facility usable into early December, although use of a four-wheel-drive vehicle was recommended.

The main Bidwell Canyon BR, a concrete ramp with seven launch lanes and a floating courtesy dock, was usable until mid-August. However, the ramp narrows to five lanes near its mid-point. By July, the water level was near the bottom of this ramp and only two lanes were effectively usable. An adjacent two-lane low-water ramp was usable until October 20, 2002, when the launch facility was closed by DPR. A limited amount of unpaved parking is available at the low-water ramp, but some boaters were forced to

park some distance away and uphill on the main ramp, or at the parking lot above the main ramp.

The Lime Saddle boat launching facility does not have a separate low-water ramp like those at the Bidwell Canyon and Spillway areas. It was available for general use until about mid-August 2002, with launching possible for boaters with four-wheel-drive vehicles for several additional weeks. The Lime Saddle ramp closed in late September 2002; DWR used the 2002 low-water opportunity to extend it to 702' in December 2002.

The two other major boat launches on the reservoir became unusable during the 2002 primary boating season. The Enterprise BR on the South Fork arm of the reservoir was usable only until early June, down to a reservoir elevation of about 835 feet. However, as late as August 31, 2002, with the pool elevation at 735 feet, vehicles were observed launching PWC and other small boats from the shoreline near the Enterprise launch. The Loafer Creek launch was closed on July 27, 2002, when the reservoir elevation was approximately 776 feet.

5.2.2.2 Historic Effects of Low Water on Usability of Lake Oroville Boat Ramps

To provide a historic perspective on the effect of Lake Oroville drawdown on the usability of the boat ramps, data were compiled on the number of days that the reservoir was below each ramp's minimal usable elevation since 1990. (Data on daily pool elevation for the years prior to 1990 are unavailable or incomplete). The focus of this analysis was on the mid-May to mid-September summer boating season, when the highest level of ramp use occurs. The DWR Lake Oroville recreation website provides boaters with the elevations at which each boat ramp is open.

The results of this analysis indicate that there were few days when all of the ramps were unusable during the summer boating season, and that this occurred only 1 year in the last 13 (Table 5.2-2). In that "worst-case" year (1990), the three lowest-reaching ramps (the lower ramps at Bidwell Canyon and Spillway, and the Lime Saddle ramp) closed in late July and early August. From 1990 to 2002, all ramps were unusable because of low water levels on about 2 percent of the summer boating season days.

At Bidwell Canyon, boaters were able to launch from the upper ramp on 88 percent of the summer boating season days from 1990 through 2002. In 5 of the 13 seasons examined, the ramp was unusable during part of the season, with an average of 40 closed days because of low water in each of those years.

The 775-foot bottom elevation at the Loafer Creek boat ramp, the most convenient ramp for boaters camping in the Loafer Creek Campground, is considerably higher than the other major ramps. Consequently, the Loafer Creek ramp was unusable for about one-third of the summer boating season days from 1990 through 2002 and was unusable for

at least part of the season in 6 out of the 13 years. The data further highlight that, in those seasons in which the ramp did become unusable, the closure typically extended over more than two-thirds of the season (an average of 87 days).

The more remote Enterprise BR is not used as heavily as the other ramps and primarily serves nearby residents. However, because it is usable only down to about the 835-foot elevation, it was unusable for at least part of the summer boating season during all but the four highest pool level years (1993, 1995, 1996, and 1998). The ramp was unusable for part of the summer season during 9 of the 13 years examined, and it was unusable for an average of 95 days (most of the season) in those years. The ramp was closed for the entire May 15–September 15 period in 5 of the 13 years. These closures are particularly notable because this is the only developed (not car-top) ramp on the eastern portion of the reservoir, and use of the other ramps requires a notably longer drive for local residents.

Table 5.2-2. Lake Oroville boat ramp closures due to low water during the May 15 to September 15 peak boating season (1990–2002).

Boat Ramp	Minimum Usable Elevation (ft. msl)	Number of Days Closed	Percent of Days Closed[1]	No. of Years Closed for Part of Season	Average Number of Days Closed[2]
Lime Saddle	727	139	9	4 of 13	35
Spillway—upper ramp	810	721	45	8 of 13	90
Spillway—lower ramp	725	125	8	3 of 13	42
Bidwell Canyon—upper ramp	735	198	12	5 of 13	40
Bidwell Canyon—lower ramp	710	36	2	1 of 13	36
Loafer Creek	775	524	33	6 of 13	87
Enterprise	835	858	53	9 of 13	95

[1] Percentages are based on 1,612 total days: 124 days (May 15–Sept. 15) x 13 years (1990–2002) = 1,612 days.
[2] Average includes only those years ramp was closed part of the season (as reported in the adjacent column).
Source: DWR 2003a (historic reservoir elevation data).

Historically, the most substantial negative effects of low water levels on the usability of the boat ramps occurred during the 4 years when both the Enterprise and Loafer Creek ramps were closed because of low water for all or most of the summer boating season. The ramps at Lime Saddle and Spillway were also closed for 30–50 days during three of those four seasons. This occurred mostly in the early 1990s, but also as recently as 2001. This is in contrast to the 5 years during the mid- and late-1990s when all of the ramps were usable through all or nearly all of the summer boating season. Conditions during the remaining 4 years were between these extremes, with a lengthy closure only at Enterprise BR.

Review of year-round reservoir elevation data indicates that the Spillway low-water ramp in particular has been essential in providing launching to boaters during all but the

lowest reservoir elevation periods of the last 13 years. That ramp has remained usable throughout all or most of the fall and winter months of most years. The Lime Saddle ramp has also provided boat access to the reservoir through most low-water periods, but with the inconvenience of a long walk up the ramp to the parking lot during low-water periods. The lower ramp at Bidwell Canyon has provided access at the lowest pool elevation (710 feet), but with limited parking (overflow parking is above, along one side of the upper ramp or in the lot at the top of the upper ramp). These three lowest-reaching ramps were never closed because of low water during the nearly 9-year period between early January 1993 and late October 2001.

5.2.2.3 Effect of the Extension of Three Major Launch Ramps

DWR completed extension of the boat ramps at Bidwell Canyon, Spillway, and Lime Saddle during December 2002. The extensions allow the ramps to be used at water elevations 10–30 feet lower than previously possible. The lower Spillway ramp has been extended to allow use of two lanes down to an elevation of 695 feet. Similarly, the Lime Saddle ramp now provides two launch lanes down to the 702-foot level. The three-lane lower Bidwell Canyon ramp has been extended down to 700 feet. Judging by historic reservoir elevation data, these extensions will make the ramps usable year-round in most years. Before 2002, March 1991 was the last time that Lake Oroville fell below 695 feet elevation. The reservoir had not been lower than 702 feet since December 1992.

Because the ramp extensions are so recent, historical reservoir elevation data provide the best means to gauge the longer term effect the extensions may have on summer use. Comparison of the actual occurrence (without the ramp extensions) with the hypothetical situation (with the ramp extensions) shown in Table 5.2-3 indicates that the Lime Saddle and lower Spillway ramps would have been unusable for part of one summer season rather than three or four from 1990 to 2002. Also, over the 13 years, each ramp would have been closed due to low water about 100 fewer peak boating season days (31 vs. 139 days at Lime Saddle and 24 vs. 125 days at Spillway).

The greater effect of the launch ramp extensions would occur during the non-summer months, when reservoir levels are lower. All three of the extended ramps are commonly used by fishermen for bass tournaments and general access, and by a lesser number of pleasure boaters, during the fall and winter. (This analysis assumes that reservoir elevation in future years will vary within a range and frequency similar to that seen from 1990 to 2002.)

Table 5.2-3. Comparison of Lake Oroville boat ramp usable days, with and without extensions, May 15–September 15 peak boating season (1990-2002).

Boat Ramp	Minimum Usable Elevation (ft. msl)	Number of Days Closed	Percent of Days Closed[1]	No. of Years Closed for Part of Season	Average Number of Days Closed[2]
Lime Saddle BR					
Without extension	727	139	9	4 of 13	35
With extension	702	31	2	1 of 13	31
Spillway BR - lower ramp					
Without extension	725	125	8	3 of 13	42
With extension	695	24	2	1 of 13	24
Bidwell Canyon BR - lower ramp					
Without extension	710	36	2	1 of 13	36
With extension	700	30	2	1 of 13	30

[1] Percentages are based on 1,612 total days: 124 days (May 15–Sept. 15) x 13 years (1990--2002) = 1,612 days.
[2] Average includes only those years ramp was unusable (as reported in adjacent column).
Source: DWR 2003a (historic reservoir elevation data).

5.2.2.4 Effect of Low Pool Levels on Number of Boat Ramp Lanes Available

In addition to effects at individual ramps, the total number of launch lanes available to boaters is progressively reduced as the reservoir level falls. This is due both to ramp closures and the narrowing of most of the primary ramps at lower elevations. A reduced number of available lanes can cause crowding and more waiting for boat launching and retrieval. Table 5.2-4 lists the cumulative lane closures that occur, first at the 850-foot elevation and continuing until all ramps are closed at the 695-foot elevation.

For about the first 80 feet of drawdown below full pool, effects of the drawdown on boat ramps is minor. All the major ramps are at or near full width, but the smaller Enterprise ramp closes at about the 835-foot elevation. The first major reduction occurs at about the 815-foot elevation, when launching is switched to the low-water ramp at Spillway, which has four fewer lanes than the upper ramp and which may result in more crowding and longer waits at that ramp during high use periods.

At 800 feet, a total of 17 launching lanes are potentially available lake-wide, reduced from the 33 lanes available between full pool and the 850-foot elevation. Most lanes of the Loafer Creek ramp are closed at 800 feet, and the floating dock is not usable. The next effects of drawdown are seen at 780 feet, and progressive closures of ramps and individual lanes continue down to the 695-foot elevation, when all ramps are closed. Loafer Creek ramp closes at 775 feet, requiring Loafer Creek campers and day users for whom that ramp is most convenient to drive several miles to the Bidwell Canyon or Spillway ramps.

Table 5.2-4. Lake Oroville boat ramp lanes lost during reservoir drawdown due to ramp closures and ramp narrowing.

Pool Elevation Reached (ft. msl)	Affected Boat Ramp(s)	Launch Lanes Lost/Gained	Total Launch Lanes Available (lake-wide)
900–851	(Full pool and first 49 feet of drawdown)	---	33
850	Bidwell Canyon – upper ramp	-2	31
835	Enterprise (closed)	-2	29
820–815[1]	Spillway - upper ramp (closed, switch to lower ramp)	-4	25
800	Bidwell Canyon – upper ramp Loafer Creek ramp Lime Saddle ramp	-1 -6 -1	17
780	Bidwell Canyon – upper ramp	-2	15
775	Loafer Creek (closed)	-2	13
763	Lime Saddle ramp	-1	12
745–740[1]	Bidwell Canyon – upper ramp (closed, switch to lower ramp)	+1	13
725	Spillway – lower ramp	-6	7
702	Lime Saddle (closed)	-2	5
700	Bidwell Canyon – lower ramp (closed)	-3	2
695	Spillway – lower ramp (closed)	-2	0

[1] *The elevations at which the upper and lower ramps at these locations can be used overlap slightly; the switch to the lower ramp will usually occur in the elevation ranges stated.*

Note: The source states the minimum usable elevation of the Enterprise Ramp is 820 feet. Field observations indicate the correct elevation is about 835 feet, as reported here.

Source: DWR 2004b.

Survey data related to boaters needing to wait to use the boat ramps indicate that Lake Oroville boaters were more likely to have to wait to use the ramp when the pool was at lower elevations. One third of boaters surveyed when the reservoir was above 850 feet said they typically had to wait to use the boat launch they most frequently use (Table 5.2-5). In comparison, the percentage who said they typically had to wait was over 50 percent among those surveyed when the reservoir was between 750 and 800 feet and was nearly 60 percent when the reservoir was below 750 feet.

Boaters who said they did typically have to wait were asked to give the average number of minutes they have to wait. Although the likelihood of having to wait appears to increase as the pool level decreases and less launch lanes are available, the length of waits appears to be less effected; the average length of wait ranged from about 8 to 11 minutes at all pool elevations.

Table 5.2-5. Percentage of boaters reporting having to wait to use launch ramps by Lake Oroville elevation at time of survey.

Lake Oroville Pool Elevation (ft. msl)	Typically have to wait to use the ramp? (percent responding "Yes")[1]
>850	33
801–850	40
751–800	51
<=750	58

[1] *Although the survey question was not asked in reference to the day of the survey, the assumption is made for this comparison that boaters were likely to respond in reference to their recent use of the ramp.*

Source: EDAW 2004.

5.2.2.5 Summary of Effects of Low Pool Levels on Lake Oroville Boat Ramps

Overall, boater access to Lake Oroville is good and is not greatly affected by reservoir drawdown until about the 800-foot elevation. An important exception to this is the closure of the Enterprise Ramp when the pool elevation falls below about 835 feet, which often occurs during the summer. The ramp at Loafer Creek is also likely to become unusable during the latter part of the summer in lower water years, requiring Loafer Creek campers and others to drive to ramps several miles away to launch. Launching is available even at the lowest pool levels likely to occur most years (below 750 and down to 695 feet), although the reduced number of ramps and launch lanes available at lower pool levels increase the likelihood that boaters will have to wait to use the ramps. Except during the most extreme low-water conditions, typical wait times do not appear to be lengthy, averaging approximately 10 minutes.

5.2.3 Effects of Low Pool Levels on Car-Top Boat Ramp Access

The five car-top boat ramps at Lake Oroville and their general locations are as follows:

- Nelson Bar Car-Top BR (west side of West Branch);
- Dark Canyon Car-Top BR (cove on east side of West Branch);
- Vinton Gulch Car-Top BR (cove on west side of West Branch);
- Foreman Creek Car-Top BR (north side of main basin); and
- Stringtown Car-Top BR (south side of Middle Fork arm).

Three of the car-top boat launches—Nelson Bar, Dark Canyon, and Vinton Gulch—are located toward the northwest end of Lake Oroville, on the West Branch arm of the reservoir. All of these facilities consist of old paved roads that continue under the reservoir, with restrooms and limited developed parking provided at full-pool elevation. (Parking at Vinton Gulch is primarily parallel parking along the roadside, and areas within the inundation zone at Foreman Creek have been marked as parking areas.) Their primary purpose is to provide opportunities for hand launching of small boats (e.g., canoes and kayaks) and access to the shoreline for non-boaters in less-developed

settings. Trailer launching of boats (primarily small fishing boats) also occurs at all of the sites, but is discouraged. At Foreman Creek and at Stringtown, some trailer launching of small boats also occurs from the shoreline.

5.2.3.1 Vinton Gulch Car-Top Boat Ramp

The Vinton Gulch facility provides a cement road running along the side of a narrow cove that allows vehicles access to the water and is suitable for trailer launching of small boats. Because the facility is toward the back of the cove, the road is out of the water earlier than at some of the other car-top boat ramps. The end of the cement road is at an elevation of about 850 feet; thus this ramp was unusable for launching throughout 2002, and did not become usable again until mid-April 2003.

Hand launching of small watercraft is possible well below the 850-foot mark, as a gradually sloping dirt track and footpath continue into the cove beyond the end of the paved road. (Figure 5.2-1 is a photograph depicting conditions at the 830-foot elevation.) However, when the pool level was just above the 800-foot elevation, the water was observed to be nearly out of sight of the road and those wishing to hand launch would have to carry their watercraft approximately 1,000 feet to reach the water. On several occasions during June, 2002, a few visitors were seen using the shoreline to bank fish. As the summer drawdown continued below the 800-foot level, the narrow cove dewatered and the shoreline was observed to become increasingly steep and the water much more distant, making both hand launching of boats and shoreline access difficult.

Figure 5.2-1. Vinton Gulch Car-Top Boat Ramp (pool elevation = 830 ft. msl).

Source: EDAW 2003.

The 1996 California State University–Chico study (Guthrie et al. 1997) noted that floating debris in this cove made the site unusable throughout the spring and early summer of 1996 (the reservoir rose from about 850 feet to full pool in that period). Floating debris was also observed in the cove during a similar period during 2003, as the reservoir filled to full pool once again.

5.2.3.2 Dark Canyon Car-Top Boat Ramp

Similar to Vinton Gulch, the Dark Canyon Car-Top BR facility is located toward the back of a fairly narrow cove. However, here the paved road extends a greater distance along the side of the cove, making the site usable for small-boat trailer launching at lower elevations than at Vinton Gulch. Figure 5.2-2 is a photograph taken when the reservoir was at an elevation of about 844 feet. It depicts a small fishing boat that had just been trailer launched from the roadbed. The road extends well beyond the point depicted.

Launching of PWCs was observed as late as August 3, 2002, when reservoir elevation was about 767 feet. However, by mid-August the end of the roadbed ramp was out of the water and some distance above it, with further use blocked by a large rock placed at the end of the ramp. The shoreline alongside and at the end of this access road is very steep, making shoreline use and hand launching of watercraft from the shoreline difficult or impossible.

Figure 5.2-2. Dark Canyon Car-Top Boat Ramp (pool elevation = 844 ft. msl).

Source: EDAW 2003.

5.2.3.3 Nelson Bar Car-Top Boat Ramp

The Nelson Bar Car-Top BR is located in a small cove closer to the main stem of the West Branch than Vinton Gulch or Dark Canyon, yet its location (well up the West Branch above the Lime Saddle area) resulted in the roadbed being out of the water during most of 2002. The roadbed is cement down to about 850 feet, and then becomes dirt. A berm prevents vehicles from launching on the roadbed below about 840 feet elevation. The roadbed beyond the berm skirts a steep hillside and has largely eroded away into the cove, rendering it usable for vehicles.

Figure 5-2.3 is a photograph taken of the roadbed when the pool elevation was at about 830 feet. The end of the paved road is located where the vehicle to the left is parked; the second vehicle is parked just above the berm. Also apparent in the image is the steep shoreline and the abrupt drop-off where the old roadbed has eroded.

Figure 5.2-3. Nelson Bar Car-Top Boat Ramp (pool elevation = 830 ft. msl).

Source: EDAW 2003.

Light use of Nelson Bar by bank anglers and swimmers was observed through August, 2002, although the shoreline below the roadbed was steep and muddy. Anglers fished from the rip-rapped side slopes of the large embankment that was placed in the back of the cove a few years ago. (The top of this embankment is the parking area.) During May, 2003, when the reservoir was near full pool, large numbers of waders and swimmers were seen gathered at the parking area, which is inundated at pool levels

above about 893 feet. Fishing access from the parking area is good at elevations from 10 feet or so below full pool.

The conclusion drawn from the above observations is that operational effects are not severe until the reservoir falls below about 840 feet, beyond which trailer launching is not possible and shoreline use is possible but conditions are not favorable. Hand launching of canoes or kayaks is possible at lower elevations, but the steep and rocky shoreline is not conducive to that use. Shoreline fishing is possible at elevations down to about 800 feet, at which point the cove is mostly dewatered, but is best at higher pool levels (above about 850 feet) when anglers can cast from the margin of the parking area or from the riprap just below.

5.2.3.4 Foreman Creek Car-Top Boat Ramp

Like the other car-top boat ramps, the main feature at Foreman Creek is an old roadbed used as a ramp to trailer-launch boats. Although it is primarily suited to launching of small fishing boats, because of the shallow angle of the roadbed, some standard-sized runabouts were observed launching from the road. Hand launching of boats also occurs on the old road and shoreline. As many as six vehicles with boat trailers were counted in the area at one time (on July 28, 2002), and several PWCs were also observed operating from the shore.

Foreman Creek is unique among the car-top boat launching ramps in that the old road also provides access to a large area of flat to gently sloping shoreline as the reservoir is drawn down. Because of the moderate slope of the land in the area, the exposed area land increases greatly as the reservoir elevation falls.

Figure 5.2-4 is a photograph taken when the reservoir elevation was about 808 feet. The image shows that the roadbed was usable for launching, and areas of nearly flat shoreline are apparent. A shoreline angler at the water's edge and a vehicle parked on the road are visible in the right side of the image.

Most of the use observed at the site consisted of non-boating groups relaxing on the shore and swimming. Twenty-one such shoreline users were counted at the site on June 30, 2002, when the reservoir elevation was about 814 feet, and 25 were counted on July 4, 2002, when the elevation was about 809 feet. Shoreline fishing activity was also observed in the area, especially early in the summer when the water is most clear (wave action frequently causes the water to become muddy, as more submerged land is re-exposed). Local residents use the area at night to fish for catfish.

Visitor use at Foreman Creek was observed to be very low by early August, when boat launching from the road was no longer possible. Some boaters who launched elsewhere used the shoreline to beach their boats and relax. Observations made from a boat on August 3, 2002, when the reservoir was at an elevation of 767 feet,

documented that large areas of previously inundated land were exposed, extending far out into the main basin of the reservoir and creating shallow bays.

Figure 5.2-4. Foreman Creek Car-Top Boat Ramp (pool elevation = 808 ft. msl).

Source: EDAW 2003.

Overall, reservoir levels down to about 800 feet do not appear to have large negative effects on the use of Foreman Creek. As the pool level decreases from full pool, the amount of usable shoreline with gradual slope increases considerably, whereas little shoreline is accessible when the elevation is at or near full pool. The roadbed allows trailer launching of boats well below 800 feet elevation, but the area may be less attractive to some shoreline users as the amount of exposed reservoir bottom increases and the vegetated shoreline becomes more distant.

5.2.3.5 Stringtown Car-Top Boat Ramp

The Stringtown Car-Top BR on the South Fork of Lake Oroville is at the end of a narrow, winding road terminating into the reservoir. The old roadbed winds around the hilly terrain a considerable distance beyond the high-water line and below the full pool elevation. The road is cement only down to about 870 feet; below that elevation, the road is asphalt in poor condition, but it is adequate for the launching use it receives. The shoreline land that is exposed as the reservoir level recedes is moderately steep in most areas. Because of this generally more-difficult access, use of the area for launching boats is less than that observed at Foreman Creek.

What appeared to be typical use was observed on Saturday afternoon, June 15, 2002, when the reservoir was at an elevation of 828 feet. At that time, there were 5 vehicles with boat trailers, 20 other vehicles, and about 30 people relaxing on the shore and swimming. Another 15 people associated with a beached houseboat and runabout also used the area. Use fell from those peak levels as the summer progressed and the reservoir level receded. Ten vehicles and 18 people were observed on Saturday, July 6, 2002; 17 vehicles and 24 people were observed on Saturday, August 2, 2002; and 7 vehicles and 12 people were observed on Saturday, August 17, 2002. No more than two vehicles with boat trailers were present on any of those dates.

During February and March, 2003, several small fishing boats were observed to have been trailer launched from the end of the road, when the reservoir elevation was just above the 800-foot level. Figure 5.2-5 is a photograph of the last few hundred feet of the old road taken on February 22, 2003. Two vehicles with boat trailers are parked at the end of the road, and three other vehicles are present.

Figure 5.2-5. Stringtown Car-Top Boat Ramp (pool elevation = 808 ft. msl).

Source: EDAW 2003.

During March 2003, shoreline use by bank anglers was observed at a pool elevation of about 825 feet, and some visitors drove their four-wheel-drive vehicles along the sloped, exposed shore. Figure 5.2-6 is a photograph of this shoreline use at Stringtown. A

vehicle is parked among the rocks in the middle of the image, and several anglers are standing at the shore.

Figure 5.2-6. Shoreline use at Stringtown Car-Top Boat Ramp area (pool elevation = 825 ft. msl).

Source: EDAW 2003.

Similar to Foreman Creek, the overall conclusion concerning Stringtown is that the highest pool levels do not allow the best access to and use of the area, and the length of the old road provides boat access to the reservoir at low reservoir elevations (down to at least 800 feet). Shoreline use also appears to be most favorable above 800 feet, although such use is possible and occurs at lower reservoir levels.

5.2.3.6 Summary of Reservoir Level effects on Car-Top Boat Ramps

The above observations indicate that hand launching of car-top boats, as well as trailer launching of PWC and other small boats, is possible from some of the car-top boat launches at reservoir elevations down to 800 feet. At some locations, hand launching of boats and shoreline activities can continue at the low reservoir elevations typical of the late summer, fall, and early winter seasons (750–800 feet). The areas become progressively more difficult to use, however, because of the increased distance to the water and steep, muddy shorelines. The Foreman Creek Car-Top BR area provides the most usable shoreline, and use of the old roadbed is least impacted by drawdown because of the gentle topography in the inundation zone. Modest drawdown of the reservoir actually improves usability of the Foreman Creek and Stringtown areas

because little shoreline access is available at those areas when the reservoir is at or near full pool.

5.2.4 Effects of Low Pool Levels on Boat-In Campsite Access

The four BICs at Lake Oroville and their general locations are as follows:

- Goat Ranch Area BICs (west side of North Fork arm, below confluence with West Branch);
- Bloomer Area BICs (three camps in same general area, west side of North Fork arm, below confluence with West Branch);
- Foreman Creek Area BICs (east side of North Fork Arm, north side of main basin); and
- Craig Saddle BIC (near confluence of Middle and South Fork arms).

Together, the four BICs provide 100 campsites: six at Goat Ranch, 46 at Bloomer (including group sites), 30 at Foreman Creek, and 18 at Craig Saddle. Access to the boat-in campsites is possible at any reservoir elevation. However, even at pool levels somewhat above 800 feet, as existed through May and June 2002, campers are faced with a considerable walk up steep shorelines to get from their boats to the campsites. An illustration of this is provided by Figure 5.2-7, which is a photograph of the South Fork approach to the Craig Saddle BIC. The photograph was taken from the surface of Lake Oroville when the pool elevation was about 830 feet. The image shows the trail up the sloped shoreline to the campsites, and gives some indication of the distance and steepness of boaters' access to the campsites at a moderate degree of reservoir drawdown. Similar conditions exist at the three other BICs.

DPR provided BIC use data for the 13 months from June 2002 through June 2003 (registration and fees are required). Use of the campsites was very low during the summer of 2002. The maximum number of sites reserved was three sites during June and four sites during July. Only one site was reserved during August and no subsequent use was recorded until May 2003. High water levels resulted in an increase in use to a modest level during May and June 2003, with the maximum number of sites reserved reaching 15 sites during May and 26 sites during June (both on weekend days). A total of 208 sites were reserved during June, which corresponds to an occupancy rate of about 7 percent for the month.

Observations of boat-in campsite use made during the summer of 2002 provide additional documentation of use of the sites, for both camping and day use, as the pool level drops. Both the Craig Saddle and Foreman Creek BICs were visited by field staff during Memorial Day weekend of 2002. The reservoir elevation was about 837 feet, near the high for the year. Ten boats, including two houseboats, were beached at the Craig Saddle location, and 6 of the 18 campsites were occupied (non-campers as well as campers appeared to use the shoreline in this area). Three boats were beached at the Foreman Creek Area site and two camping groups were present. At both sites,

visitors were required to walk several hundred feet up the steep shoreline to reach the campsites.

Figure 5.2-7. South Fork access to Craig Saddle Boat-In Campsites (reservoir elevation = 837 ft. msl).

Source: EDAW 2003.

On Sunday morning, June 16, 2002, a visit to the Bloomer Area BICs revealed only one boat beached on shore and two sites occupied. (Ten persons were at the Bloomer Group Camp, but they most likely did not boat in.) As observed at the other boat-in campsites, campers were required to walk a considerable distance from the shore up to the campsites because of the low elevation of the reservoir (about 828 feet). Visits conducted on the same morning to the Goat Ranch Area, Foreman Creek Area, and Craig Saddle BICs revealed that all three campgrounds were vacant.

On Sunday morning, June 23, 2002, the Goat Ranch Area BICs were once again unoccupied while two boats were beached near the Bloomer Area BICs, and one group camp site was occupied. Survey crew members visiting the Foreman Creek BIC found it unoccupied. Staff members arriving at the Craig Saddle BIC at 12:30 p.m. found two boats on shore and three sites occupied. The reservoir elevation on that day was about 822 feet.

Because of the low use of the boat-in campsites, survey crews did not continue to regularly visit those sites for visitor surveys and to monitor use after late June. The final

observations of use at boat-in campsites were conducted on Saturday afternoon, August 3, 2002, in conjunction with observation of boat traffic for Study R-7 – *Reservoir Boating*. The observer passing by the Foreman Creek, Bloomer Area, and Goat Ranch Area BICs between 4:00 and 4:30 p.m. recorded no boats present at any of those sites. The reservoir elevation on that date was about 767 feet. Figure 5.2-8 is a photograph of the shoreline below the Foreman Creek Area BICs taken when the water was at that approximate elevation. Most noticeable is the length and steepness of the access from the boat to the campsites.

Figure 5.2-8. Boater access as seen from the Foreman Creek Area Boat-In Campsites (pool elevation = 765 ft. msl).

Source: EDAW 2003.

5.2.5 Effects of Low Pool Levels on Swimming Access

The most easily observed effects of low pool levels on swimming access occur at the Loafer Creek DUA. However, effects also occur at other less-developed sites around the lake, such as the car-top boat ramps.

5.2.5.1 Swim Beach at Loafer Creek Day Use Area

The swim beach at Loafer Creek DUA is the only designated swim facility on Lake Oroville. DWR's report *Assessment of Recreation at Lake Oroville* (DWR 1992) states that the beach becomes inoperable at an elevation range of 860–875 feet. Using the 860-foot elevation as the minimum usable elevation, historical reservoir elevation data

from 1990 to 2002 indicates that the beach was below this threshold for at least part of the summer recreation season in 11 of those 13 years (Table 5.2-6). In 6 of those 11 years, the facility was distant from the water during the entire May 15–September 15 period. These conditions persisted anywhere from 36 to 81 days during the remaining five seasons.

Table 5.2-6. Frequency that Loafer Creek swim beach was subject to sub-minimum usable reservoir surface elevation, May 15–September 15 (1990–2002).

Facility	Minimum Usable Water Elevation (ft. msl)	Number of Days Below Minimum Elevation	Percent of Days Below Minimum Elevation[1]	No. of Years Unusable for Part of Season	Average Number of Days Unusable[2]
Loafer Creek swim beach	860	1,027	64	11 of 13	93

[1] Percentage is based on 1,612 total days: 124 days (May 15 to September 15) x 13 years (1990 to 2002).
[2] Average includes only the 11 years during which the beach was unusable (as reported in the adjacent column).
Source: DWR 2003a (historic reservoir elevation data).

The beach facility was unusable for swimming at the start of study data collection on Memorial Day weekend in 2002, when the reservoir was at an elevation of about 837 feet. However, a minor amount of swimming activity was observed early in the summer of 2002, although the facility was not usable as designed and access to the water required walking a considerable distance down the steep shoreline. On Saturday afternoon, June 1, 2002, nine people were observed swimming, eight people were picnicking and relaxing, and five people were associated with a houseboat moored nearby. Several of the visitors observed stayed for only about 15 minutes. No swimmers were observed during several visits to the area through the rest of the summer. Visitors were observed spending just a few minutes walking around the area, or leaving as soon as they observed the conditions (presumably because the water level was so low and the shoreline so far away).

During the 2003 summer recreation season, Lake Oroville remained within a few feet of full pool (900-foot elevation) through June before being reduced by 1–1.5 feet per day during July. This high pool level permitted the Loafer Creek swim beach to be usable until late July. Although no specific visitor count was conducted, several dozen picnickers and swimmers were observed using the area on the afternoon of Friday, June 27, 2003. Observations made from a boat on Saturday, July 26, 2003, when the reservoir elevation was at about 860 feet, indicated that the swim beach cove was mostly dewatered and use by swimmers had become minimal.

5.2.5.2 Other Lake Oroville Swimming Locations

Lake Oroville visitors use various other locations as informal swimming areas. Several of the car-top boat ramp areas receive increased use by swimmers as the reservoir level decreases. Observations conducted for Study R-9 – *Existing Recreation Use*,

indicated that a minor amount of swimming occurred at most of these sites, while the dominant uses at these sites were shoreline picnicking by boaters and non-boaters, bank angling, and PWC use. The exception to this use pattern is the Nelson Bar Car-Top BR, which was observed to receive considerable use by swimmers early in the 2003 summer season when the reservoir was near full pool and the parking area was inundated, providing a large, relatively shallow area to swim. Lesser numbers of swimmers were also observed at that time at each of the other car-top boat ramps.

After the launch ramp at Loafer Creek was closed on July 27, 2002, because of low water, small groups of visitors were observed using the shore area at the base of the ramp to swim and relax. The location is not well suited for that use, however, as the shoreline is very steep and muddy. The main attraction of the location appeared to be the easy access to the shoreline via the paved ramp and the ability to park vehicles nearby on the ramp. Similar activity occurs in the Bidwell Canyon area and other shoreline locations accessible to non-boating visitors, but most such areas are also characterized by the steep and muddy condition of the shore as the reservoir recedes.

5.2.6 Effects of Water Temperature on Swimming

Data on water temperatures in Lake Oroville, Thermalito Forebay, Thermalito Afterbay, and the Feather River were reviewed in Section 5.1. Those data indicate that the surface water temperature at several locations within Lake Oroville was within a comfortable range for swimming (approximately 70–80°F) throughout the summer. Temperatures downstream from Oroville Dam were shown to be much cooler as a result of the release of water from the reservoir hypolimnion[3], where the temperature remains at 45–50°F throughout the summer. No swimming was observed in the Thermalito Diversion Pool and little was observed in the Feather River during the study period, presumably because of the cold water temperatures.

5.2.6.1 Swimming in Thermalito Forebay

The water temperature data for Thermalito Forebay reviewed in Section 5.1.2.2 indicated that the water entering Thermalito Forebay from the Thermalito Power Canal is not warmer than about 60°F at any time during the summer. However, surface water temperature near the swim beach within the North Thermalito Forebay DUA was found to be as much as 15°F warmer. Apparently, the location of the swim beach on a small, shallow basin (about 0.2 mile wide) narrowly connected to the main body of the North Thermalito Forebay reduces circulation in this "lagoon" and permits some solar heating of the surface water. Although the water temperature in the lagoon a few feet below the surface was found to be nearly as cold as the water temperature in the main body of Thermalito Forebay, it was observed that most swimmers and waders at the beach (particularly small children) stay in the shallower water close to the beach, and so may avoid the colder water. Observations of high numbers of beach users suggest that,

[3] The layer of water in a thermally stratified lake that lies at deeper levels, is non-circulating, and remains perpetually cold.

although water temperatures may not be ideal, the colder water below the surface layer does not discourage use of this area for swimming and wading.

5.2.6.2 Swimming in the Feather River

Available data suggest that water temperatures in the Feather River are in the range of 60–65°F throughout the summer (see Section 5.1.3.1). The Oroville Facilities are operated so that temperatures stay close to this range to benefit the coldwater fishery in the river (see Section 1.4.1). Shutters on the intake structures for Hyatt Pumping-Generating Plant allow reservoir operators to draft water from discrete reservoir depths, to ensure that the water being released is in the range of 45–50°F.

Swimmers can access the LFC from the riverbank levee north of downtown Oroville, from Riverbend Park and adjacent Bedrock Park, and from various riverbank locations in the OWA. Paved bike paths and gravel roads provide access to all three locations. However, observations indicate that most of the visitors entering the river from these three locations are wading anglers, who are typically affected more by flow variation than by cold water temperatures. Wading anglers are also the primary shore-based users of the river below the Thermalito Afterbay outlet, gaining access to the riverbank through gravel roads in OWA.

Issues scoping for the Alternative Licensing Procedure indicated that some stakeholders would prefer the Oroville Facilities to be operated in a manner that would provide additional cold water to the LFC and colder water to the river below the Thermalito Afterbay outlet to further benefit salmon and steelhead species of fish. Other stakeholders would prefer warmer water in the LFC to improve conditions for swimming and other water-contact recreation.

In addition to constraints related to hydrology, flood control needs, and water delivery commitments for agricultural, urban, and environmental uses, the range of operational alternatives is limited by the minimum water temperature requirements of rice farmers and maximum water temperature requirements to maintain the coldwater fishery and for water supplied to the Feather River Fish Hatchery. As discussed in Section 1.4.1, a 1983 agreement between DWR and DFG specifies water temperature objectives for the Feather River Fish Hatchery. These objectives range from 55°F to 60°F through the summer months, considerably colder than desirable for swimming.

5.2.7 Effects of Flow Rates and Temperatures on Fishing

Flow rates and water temperatures affected by project operations are the primary factors affecting fishing on the Feather River. The several studies focused on Feather River fisheries, directed by the Environmental Work Group, highlight the relevance and importance of project operation effects on fishing in the river. Some effects of operations on fishing on Lake Oroville have also been identified and are discussed below.

5.2.7.1 Fishing in the Feather River

Under current operations, the volume of flow in the Feather River LFC (upstream of the Thermalito Afterbay outlet) is essentially steady through the year, while flows vary substantially through the year below the outlet, depending on the amount of water passed through the Thermalito Complex (Section 5.1.3.2 describes Feather River flows). The temperature data reviewed in Section 5.1.3.1 indicate that the temperature of the river changes only gradually through the year and is in the 60s (°F) through most of the summer. The water usually warms as it moves downstream. River temperatures are generally in the 50s during the prime fall steelhead and salmon fishing months of September and October and are between 45 and 50°F (only slightly warmer than Lake Oroville) through the winter and early spring. Temperatures are regulated during much of the year by drawing water released at Oroville Dam from lower, colder strata of Lake Oroville to benefit the coldwater (salmon and steelhead) fishery. The continued dominance of these fish species, and thus continued opportunities for salmon and steelhead fishing, are largely dependent on adequate flows of sufficiently-cold water.

The flow of the LFC was described in Section 5.1.3.2 as being steady at about 600-700 cfs through most of the year. The flow below the Thermalito Afterbay outlet was described as increasing in step-wise fashion during the summer months before being reduced in a similar fashion after a midsummer peak. Both direct and indirect effects of changes in flow rates may occur. Informal interviews with river users suggest a direct but temporary effect on fishing may exist when flows in the LFC are steeply increased for a period of a few days, as occurred August 26–28, 2002, making wading and boating more difficult. Similarly, the increased summer flows below the Thermalito Afterbay outlet may also make wading and boating more difficult. However, numerous fishing boats are regularly seen near the Thermalito Afterbay outlet during high flows, because of the concentration of sport fish in that area as a result of the outlet releases.

Changes in Oroville Facilities operations that would affect the amount, timing, or temperature of flows released from Lake Oroville into the river would clearly have an effect on important fisheries. Fisheries Study F-10 – *Evaluation of Project Effects on Salmonids and Their Habitat in the Feather River Below the Fish Barrier Dam* alludes to potential operational changes that could provide increased flows of cold water to improve fish habitat and survival (DWR 2003c).

5.2.7.2 Fishing in Lake Oroville and Other Project Reservoirs

Flow rates and temperature have less relevance to fishing on Lake Oroville, outside of effects of reservoir drawdown on shoreline and boat access as discussed elsewhere in this report. Lake Oroville's temperature profile is relatively unchanged from year to year, despite reservoir drawdown and surface elevation differences. Also, Study F-3.1 – *Evaluation of Project Effects on Fish and Their Habitat within Lake Oroville, Its Upstream Tributaries, the Thermalito Complex, and the Oroville Wildlife Area* indicates that the primary negative effects of project operations on the Lake Oroville fishery are related to seasonal reservoir drawdown rather than to flow or temperature.

(Specifically, changes in water surface elevation affect the availability of warmwater fish spawning and rearing habitat and may cause nest mortality. Project operations may also affect the availability of salmonid spawning and rearing habitat and accessibility to upstream tributary habitat.)

Like Lake Oroville, Thermalito Afterbay supports both coldwater and warmwater fish species. The primary effect of operations on fish (and fishing) at Thermalito Afterbay as described in Study F-3.1 relate to elevation fluctuations (daily and weekly, rather than seasonal). The primary potential effect of project operations on fish in Thermalito Forebay and the Thermalito Diversion Pool is water temperature, particularly as required to support the predominantly coldwater fishery in those water bodies.

5.3 EFFECTS OF PROJECT OPERATIONS ON RECREATION EXPERIENCES

The primary sources for information on the effects of Oroville Facilities operations on recreation experiences are survey responses obtained from visitors to the Oroville Facilities. Several specific portions of the On-Site Survey data are particularly informative. Boaters and anglers contacted on-site were asked whether they were satisfied with their boating or fishing experience and, if not, why. After completing the survey questions, visitors were asked whether they had any additional comments. Many respondents provided written comments; in most cases, responses were just a few words, but some were several sentences in length.

The follow-up Mail-Back Survey contained a question asking visitors whether they considered 25 specified issues to be a problem at the area they visited. Responses were given on a four-point scale ranging from “not a problem” to “a big problem.” Four of the 25 items related closely to water levels. The Mail-Back Survey also provided respondents with another opportunity to give additional written comments on any topic they chose. Most gave a comment and many were fairly lengthy, perhaps because they took more time to consider and write responses at home than while on-site.

Finally, a limited number of Lake Oroville visitors were sent a two-page Supplemental Survey (Appendix A) intended to provide more specific data on the effects of low pool levels at Lake Oroville. Several of the same reservoir water-level topics covered in the On-Site and Mail-Back Surveys were addressed. The results are summarized within the appropriate sections below.

5.3.1 Visitors’ Opinions on Overall Reservoir Conditions at Low Pool Levels

Lake Oroville visitors who received the follow-up Mail-back Survey were asked whether four low-water-related issues were problems at the area where they were surveyed. The issues were: access to the shoreline, exposed land during low water, water level fluctuation, and shallow areas during low-water conditions. The first three of these issues could affect both boaters and non-boating visitors, while the last issue would be expected to primarily affect boaters.

The issue of access to the shoreline is addressed in Section 5.3.5 below. The responses to the remaining three issues, addressed here, suggest that substantial portions, and in some cases a majority, considered these to be at least moderate problems. From 29 to 35 percent considered these issues to be big problems (Table 5.3-1). Respondents who were uncertain or who felt an item did not apply to them were asked to check "N/A" on the survey booklet; those responses are not included in the percentages reported here.

The highest level of concern appears to be with exposed land during low-water conditions, with approximately 55 percent indicating that this was a moderate or big problem (more than one-third of respondents considered it to be a big problem). Concern about water level fluctuation (which at Lake Oroville refers to falling reservoir levels during summer and fall) was nearly as high, with 48 percent considering it to be at least a moderate problem and more than one-third of respondents considering it to be a big problem.

Table 5.3-1. Visitors' opinions about whether low-water-related issues were a problem at Lake Oroville during their visit (Mail-Back Survey).

Issue	Percent of Responses			
	Not a problem	A slight problem	A moderate problem	A big problem
Exposed land during low water	27%	18%	19%	35%
Water level fluctuation	38%	15%	14%	34%
Shallow areas during low water	31%	22%	19%	29%

Note: Totals may not equal 100 percent because of rounding; "N/A" responses are not included in totals; n = 632.
Source: EDAW 2003b.

About the same proportion of visitors considered shallow areas during low water and water level fluctuation to be at least a moderate problem (48 percent), but somewhat fewer considered shallow areas to be a big problem. From 15 to 18 percent of respondents offered no opinion about the three issues.

The two-page Supplemental Survey conducted for this study contained a question on the aesthetic effects of low water levels, which could affect all types of visitors (boaters and non-boaters). Respondents were asked to indicate from among four response choices how much the appearance of the exposed shoreline detracted from their visit. (The question was asked in reference to their most recent experience with what they considered to be low-water conditions at the reservoir.) About one-half of the respondents indicated that it "greatly detracted" and about one-quarter felt that it "moderately detracted" from their visit.

Lake Oroville visitors who gave written comments expressing concern or complaints about low pool levels generally did so from one of two perspectives: as a boater or as a

non-boating shoreline user. Therefore, the following discussion (Sections 5.3.2, 5.3.3, and 5.3.4) separates opinions related to boating conditions and utility of boat launching and docking facilities from opinions related to non-boating shoreline use. (Some visitors contacted at sites other than on Lake Oroville—at Thermalito Forebay and Thermalito Afterbay, for example—provided comments relating to low-water conditions on Lake Oroville based on their existing knowledge and past experience with the reservoir.)

5.3.2 Visitors' Opinions about Boating Conditions at Low Pool Levels

Insight into the effects of Oroville Facilities operations on boating conditions and experiences is provided by responses to On-Site Survey questions about visitors' satisfaction with their boating and fishing experiences and their written additional comments. Most of those who responded to the Supplemental Survey were boaters; their responses are summarized at the end of this section.

5.3.2.1 Lake Oroville Boater and Angler Satisfaction as it Relates to Low Water Levels

About 11 percent of Lake Oroville boaters (134 of 1,191) surveyed on-site said that they were not satisfied with their then-current boating experience. Of those who were not satisfied, 41 percent (55 of 134) mentioned low water levels as a reason. About 22 percent of Lake Oroville anglers (206 of 944) indicated that they were not satisfied with their fishing experience and 16 percent of those (33 of 206) mentioned low water levels as a reason. (Some of the anglers surveyed fished from the shore rather than a boat. They would not have been affected by or commented on boating conditions, but their bank fishing experience could also be affected by low water levels.)

When comparing across all reservoir elevations that existed during the study period (between approximately 700 and 900 feet), there is no statistically significant relationship between boaters' and anglers' overall satisfaction with their boating or fishing experience and reservoir elevation on the day of their On-Site Survey. The relationships are statistically significant when the comparison is restricted to survey responses associated with elevations above 850 feet versus elevations below 850 feet (the chi-square tests were significant at $p < .05$). However, in both cases the percentage differences are not large, and satisfaction is high at all elevations. About 96 percent of boaters contacted when the pool elevation was at or above 850 feet were satisfied with their experience, versus 88 percent at lower elevations. The difference was slightly larger among anglers, with about 88 percent of those contacted when the pool elevation was above 850 feet satisfied versus 77 percent among those contacted when the pool was at lower elevations.

5.3.2.2 Written Comments from Visitors on Effects of Low Pool Levels on Boating

About 46 percent (1,194 of 2,583) of the visitors contacted on-site (on Lake Oroville and at downstream sites) provided additional comments at the end of the survey booklet. About one-quarter of all comments related in some way to low water levels in

Lake Oroville. About 17 percent of the comments expressed general concern or complaints about low water levels in Lake Oroville and releases downstream (e.g., "fill the lake," "keep water level up," "need more water," "the lake is too low"). Another five percent mentioned specific negative effects on boating or boating facilities of low water levels (e.g., "the boat ramp is out of the water much too often," "lower lake level makes ramp availability difficult and inconvenient," "need shuttle for parking areas—too far from water").

About 65 percent (696 of 1,071) of respondents to the follow-up Mail-Back Survey provided additional comments, and nearly 40 percent of those (264 of 696) specifically mentioned low water levels in Lake Oroville as one of their concerns. The most common statement was "the lake level is too low" or something similar. However, many respondents, particularly boaters contacted in late summer and fall of 2002, provided more specific comments on the effects of low water on their boating experience. Some examples of typical comments, and the date and location of the original On-Site survey contact, are listed below. (Note that recreation spending was the main focus of the Mail-Back Survey; several visitors also described how their recreation spending was reduced as a result of low water levels. Most of those comments are omitted here. Recreation spending is addressed in Study R-18 – *Recreation Activity, Spending, and Associated Economic Impacts*.)

- "Will not return to Lake Oroville until water level is up. Hundreds of feet of dirt is not pleasant scenery for kayaking. We'll spend our money in Redding and go to Whiskeytown where the water level is constant." (Lime Saddle BR, September 7, 2002)
- "When we fish, camp, [or] rent a houseboat, it is very important for the water level at the lake to be at a good level. We cancelled our family reunion at Lake Oroville due to low water." (North Thermalito Forebay BR/DUA, September 2, 2002)
- "Keep the water in the lake. You want lake tourism but about all that's left is a mud hole. On windy days the mud from the shoreline goes halfway across the lake." (Spillway BR, August 31, 2002)
- "…the lake being 100+ feet down by the beginning of August is appalling. That would be an acceptable level AFTER Labor Day. It is hard to recreate on the lake when the lake is shrunken. In weekends it is near impossible to find an area to ski with my young children without over-competing for lake space with many other boats." (Spillway BR, August 5, 2002)
- "We are houseboat owners and lake users for many, many years.…The fluctuating water levels are unacceptable both for the hazards and lack of areas to ski and houseboat." (Bidwell Canyon BR, September 14, 2002)
- "Unsatisfied with lake level over the last two years. Too much washed out shoreline. Boating area access is hard to work when lake level is too low. Boating experience more pleasurable when the water is higher. Also, fishing is better." (Spillway BR, August 5, 2002)

- "Lake water levels are a problem for boating use and safety….have had problems being stuck in mud because of rapid lowering overnight. Exposure of clay and mud always creates extra work on houseboats." (Bidwell Canyon BR, August 18, 2002)

5.3.2.3 Boaters' Responses to Supplemental Survey on Low-Water Levels

Five questions on the Supplemental Survey were directed specifically at boaters. Nearly all of the survey respondents indicated they had experienced low reservoir levels at Lake Oroville during the last three years, and nearly all of those had boated on the reservoir when the reservoir was low. Most of these were recent experiences that occurred during the summer and fall of 2002. In reference to their most recent boating experience when the reservoir level was low, 63 percent (45 of 72) responded "yes" when asked whether they felt more crowded than at higher reservoir levels, and 74 percent (53 of 72) responded "yes" when asked whether they felt more concerned about the safety of boating on the lake than when the water was higher.

About 80 percent of the boaters said the low water levels had other effects on their boating, which they specified. The most common effects listed were concerns caused by submerged obstacles (19 mentions); debris, rocks, or exposed shore causing boat damage (10 mentions); inability to reach certain places by boat (6 mentions); and limitations on water skiing (5 mentions).

5.3.3 Visitors' Opinions on Utility of Launching and Docking Facilities at Low Pool Levels

No survey questions specifically addressed the effect of low pool levels on boat launching and docking facilities. However, as described above, some of the boaters who provided additional written comments expressed concerns and complaints related to this issue. Several representative examples of these comments (from both the On-Site and Mail-Back Surveys) follow.

- "Way too many people trying to use a two-lane launch ramp [to go] fishing and skiing. Then you have to park your truck way up the hill and walk back through 2 inches of powder dirt and dust. It's just not very pleasant to go when the water is so low." (Bidwell Canyon BR, September 14, 2002)
- "The water level drops so low each year. Most of the ramps are not usable or you're in mud." (Spillway BR, August 31, 2002)
- "Low water poses a grid lock [problem] at launch areas. Only one ramp and short dock open on our trip. Parking a big problem when water is low; 45 minutes to one hour to put in." (Bidwell Canyon BR, September 28, 2002)
- "Water level drops too early in season…launching facilities become inadequate when water level is low, and seems to recur yearly. Need to anticipate this and provide more launch/dock facilities." (Spillway BR, July 13, 2002)

- "I would like to see the ramp at Enterprise extended (by dirt or gravel) so as to be usable when the lake is low." (Enterprise BR, July 21, 2002)
- "At the middle to end of season we are unable to use Loafer Creek boat ramp. This makes the other two boat ramps very crowded, especially during a bass fishing tournament." (Loafer Creek BR, July 7, 2002)

One question on the Supplemental Survey asked specifically about boat launching at low water levels. When asked whether, during their most recent experience with low water, they had difficulty launching their boat because of the low water, 65 percent (47 of 72) responded "yes."

5.3.4 Visitors' Opinions about Shoreline Access, Swimming, and Other Shoreline Uses

Lake Oroville visitors who received the Mail-Back Survey were asked to rate access to the shoreline as a problem during their visit. About 15 percent considered it to be a moderate problem and 19 percent considered it to be a big problem (Table 5.3-2). Among the 25 potential problem issues presented to visitors in the survey, the over 33 percent who considered shoreline access to be at least a moderate problem is relatively high. However, they expressed a lower level of concern than the 48–55 percent discussed earlier who considered other low water issues to be at least moderate problems.

Table 5.3-2. Visitors' opinions about whether access to the shoreline was a problem at Lake Oroville during their visit.

Respondents	Responses			
	Not a problem	A slight problem	A moderate problem	A big problem
All respondents	47%	20%	15%	19%
Boaters[1]	51%	19%	14%	17%
Non-boaters	40%	20%	16%	23%

[1] Categorization of respondents was based on respondents' primary activity. Boaters included boat anglers and pleasure boaters (motor boaters, PWC users, water skiers, etc.). Totals may not = 100 percent due to rounding error; "N/A" responses are not included in the totals; n = 632.
Source: EDAW 2003a.

In general, shoreline access would be expected to be less of a problem for boaters than for non-boaters during most of the drawdown period. Even at relatively high pool levels, non-boaters accessing the shore are required to walk down steep slopes, and many shoreline areas are rocky or muddy rather than sandy. In contrast, boaters do not have to descend steep slopes to reach the water, and many use the shoreline only to moor or beach their boat for part of the day while relaxing, swimming, or fishing from the boat or nearby on the shore. This difference appears to be reflected in the data, with 23

percent of non-boaters considering shoreline access to be a big problem as compared to 17 percent of boaters.

Past studies at Lake Oroville have also identified an interest among visitors in improved shoreline access. The 1996 *Lake Oroville State Recreation Area Recreational Use Study* (Guthrie et al. 1997) presented "more access for fishing and swimming" to area visitors as one among 16 potential future facility or program additions. Respondents were asked to provide their opinion of the priority each of these potential additions should have. This particular addition was rated as a "high priority" by 48 percent of the respondents, which gave it a rank of fourth among the 16 potential new facilities or programs. The top three ranked items—security patrols in the parking lots, stocking more fish, and enforcement of laws and regulations—received only 2–5 percent more "high priority" ratings.

5.3.4.1 Written Comments from Visitors on Effects of Low Pool Levels on Shoreline Access, Swimming, and Other Shoreline Uses

Some Lake Oroville visitors provided additional written comments expressing concerns and complaints related to shoreline issues. Several representative examples of these comments from the Mail-Back Survey and the Supplemental Survey are provided in the following section.

Mail-Back Survey Comments

About 18 percent of the 958 additional comments provided by respondents to the Mail-Back survey expressed complaints about their ability to use the shore for picnicking, relaxing, swimming, and other day-use activities. Many of these visitors explicitly referred to the limitations they encountered trying to enjoy the water and use the shoreline as non-boaters. Others were boaters who wanted to use the shoreline. Following are several comments that best express these types of concerns. Some of these visitors were commenting on conditions early in the 2002 season (May and June) when the water level in Lake Oroville was still well over 800 feet in elevation.

- "Would not visit Lake Oroville again. Did not have a boat and had no shoreline access to get to the lake for shore fishing due to low water level." (Bidwell Canyon Campground, August 4, 2002)
- "The lake is too low…there is hardly any access to the water safely along the shoreline. We need beaches…my kids can't swim in the lake cause (sic) all access is a huge cliff." (Loafer Creek Horse Campground, May 26, 2002)
- "We love the lake for boating, skiing, fishing, etc. but unless we're on the lake in our boat, there are no facilities to take our family fishing or swimming after the 4th of July. Either the lake level should remain higher or more facilities need to be constructed for lower water." (Foreman Creek Car-Top BR, July 6, 2002)
- "We go to the lake once or twice a year to take the kids. But there is never enough water up high for them to go swimming. I am disabled and can't walk all the way to the water. It would be nice to see the water at the shore so we could

all have fun together." Also: "The campsite was OK, but we like camping near water and because the water level was so low, we left early. There was no place to go swimming or take the dog. Maybe it would be OK if we had a boat to swim from, but we don't. We won't be going back anytime soon." (Loafer Creek Campground June 30, 2002)

- "Water level is too low for families without boat to enjoy. The walk was far to carry food, beverages, fishing equipment, rafts, and chairs. The campsites were good but to get to the water was a challenge. We have young children." (Lime Saddle Campground, July 20, 2002)
- "Water level fluctuation is a huge problem on this lake! Low water drives people away. As we get older we will not use this lake due to low water levels and poor access to shoreline." (Bidwell Canyon BR, August 18, 2002)
- "The lake is lowered so much so fast that the banks are muddy and [we are] unable to use areas for picnicking and swimming on shoreline." (Bidwell Canyon Campground, May 25, 2002)
- "The area to swim amounted to +/- 50 feet. Of the 10 groups there, only one group had reasonable access to the water. Obviously this is not an approved swim area, but where on the west shore of the lake is an area to swim? This was a day trip to allow children to swim and frolic in the water. Of the children brought to this area, a general consensus was that none would like to return." (Nelson Bar Car-Top BR, July 7, 2002)
- "The lake's too low. It is really hard to find somewhere to do swimming without having to walk a long distance. It makes it hard to enjoy ourselves." (Stringtown Car-Top BR, July 2, 2002)

A few additional respondents specifically mentioned the difficulty of using the boat-in campsites when the water level drops. The following comment illustrates this problem: "I love the boat-in campsites but with the lake level so low it is impossible to use. Who wants to hike uphill 200 feet in the heat?" (The visitor was surveyed at Bidwell Canyon BR, September 28, 2002, when the reservoir elevation was 719 feet.) The DWR *Assessment of Recreation at Lake Oroville* report (DWR 1992) states that "boat-in camping is lost—too far from water to campsites" at an elevation range of 860–875 feet.

Shoreline Users' Responses to Supplemental Survey Questions on Shoreline Use

Four questions on the two-page Supplemental Survey were directed specifically at shoreline users (some of whom are also boaters). About 60 percent of the survey respondents had used the shoreline to fish, picnic, swim, or do other non-boating activities during their most recent "low-water" visit to Lake Oroville. They had used many areas of shoreline across the reservoir, in both developed and undeveloped areas. When asked whether they had difficulty getting to the shore, 57 percent said "yes." When asked whether they found it difficult to use or enjoy the reservoir shoreline to swim, picnic, fish, etc., at the location they used, 68 percent said "yes." Seventy percent said there were additional effects of low water levels on their shoreline use,

although many did not specify what those effects were. Among the most common effects that were specified were muddy shore areas, and steep and/or unsafe foot access to shoreline.

5.3.5 Effect of Reservoir Level on Visitors' Overall Satisfaction

The survey data indicate that reservoir drawdown can have several potential negative effects on visitors' use and enjoyment of Lake Oroville. However, this is not reflected in the responses that visitors gave regarding their overall satisfaction with their visit. Measured using a 9-point scale, with 1 meaning "extremely dissatisfied" and 9 meaning "extremely satisfied," about 70 percent of Lake Oroville visitors gave a response of 7 or higher (satisfied to extremely satisfied). Further, no statistical relationship was found between visitors' overall satisfaction response and the reservoir elevation on the day they were surveyed.

The high rate of satisfaction among survey respondents does not negate the correlation of reservoir level and visitor satisfaction supported by other data. Rather, several other factors can prevent this relationship from appearing in "overall satisfaction" responses. First, visitors most affected or bothered by low reservoir levels are more likely to stop visiting during those times and thus to be unavailable to be surveyed. Second, responses to overall satisfaction are known to social scientists to typically elicit high positive responses, even from those who voiced concerns or complaints. Third, several factors other than reservoir level, such as facility management and cost of the visit, can influence overall satisfaction. Also, expectations based on word of mouth or prior experience can affect satisfaction.

5.3.6 Visitors' Opinions on Potential Management and Facility Improvements

Several comments listed in the previous section stated that facility improvements are needed to facilitate boat launching and shoreline use at lower water levels. Most often, these comments requested longer and wider ramps for low-water use. (The surveys were conducted before the ramp extensions were completed in December 2002.) A few users of the launch ramps at Lime Saddle, Bidwell Canyon, and Spillway also requested some type of shuttle from the foot of the ramp to the parking area when the reservoir is low. Many comments make no specific requests for facilities but instead point out facility shortcomings, especially for shoreline use.

As for management improvements that might improve recreation experiences during low-water periods, only two suggestions were made, each by just a few visitors. The first request was for more control or authority (a park ranger) at the launch ramps to facilitate traffic flow and keep boaters from causing congestion at the ramp or dock. The second request was for more marking of rocks and other hazards resulting from low water levels.

Whether or not they personally experienced low reservoir levels, respondents to the two-page Supplemental Survey on water level effects at Lake Oroville were asked to describe any actions that they thought could be taken to reduce the effects that reservoir drawdown has on recreational use. Most respondents provided at least one specific response. Most of the responses were requests to reduce or change the timing of outflow from the reservoir. However, several others mentioned facility-related actions such as extending launch ramps (they may not have been aware of the extensions completed during the prior winter), and providing better parking and shoreline recreation areas for low-water periods.

5.4 POTENTIAL FOR EFFECTS OF FUTURE OPERATIONAL SCENARIOS

Potential effects of future operational scenarios were assessed through the use of several types of models. These include preexisting operations-related models used by the Engineering and Operations Work Group and recreation-related models developed for the Recreation and Socioeconomics Work Group. The several complex project operations models were developed by federal agencies, DWR, and private water resource consultants. The recreation models were developed for the relicensing effort as part of Study R-12 – *Projected Recreation Use*.

5.4.1 Recreation Attendance Modeling

Two recreation attendance models were developed for Study R-12 – *Projected Recreation Use*: a Lake Oroville Recreation model and a Forebay Recreation model. Because the necessary attendance data were not available, models were not developed for other areas of the Oroville Facilities such as Thermalito Afterbay and Oroville Wildlife Area. Appendix B of Study R-12 – *Projected Recreation Use* provides a full description of the models developed and the variables evaluated. It also provides more specific description and quantification of the effect of reservoir drawdown and other factors on attendance.

The recreation attendance model for Lake Oroville established that low pool levels in Lake Oroville can negatively affect recreation attendance at the reservoir. As summarized herein, the model results estimated that a 1 percent increase in the average reservoir level (e.g., from 800 feet to 808 feet) during a July–June fiscal year would result in an increase of 13,084 visitors during that year, based on 2000 population levels and holding all other factors constant. (A yearly trend variable was also found to be a statistically significant factor in determining attendance. The overall model explained 78 percent of the variability in annual attendance at Lake Oroville.)

The recreation attendance model for Thermalito Forebay indicated that low pool levels in Lake Oroville can positively affect recreation attendance at Thermalito Forebay. The explanation for this effect is that lower water levels drive visitors away from Lake Oroville to recreate at Thermalito Forebay, which serves as a substitute site for some activities, in particular swimming, bank fishing, and picnicking. However, while the overall model explained roughly 68 percent of the annual variability in attendance at

Thermalito Forebay, Lake Oroville elevation accounted for less than 3 percent of that explained variability. In comparison, gasoline price accounted for about 45 percent, and a time trend variable accounted for about 20 percent.

Operations modeling results that quantify potential changes in average reservoir level under different operational scenarios can be used as inputs to the Lake Oroville recreation attendance model. These results can then be used to estimate the effects of those scenarios on visitation to Lake Oroville. Due to the weakness of the relationship found between Lake Oroville pool level and Thermalito Forebay attendance, the Thermalito Forebay model will not be used to predict future attendance at Thermalito Forebay based on future Lake Oroville pool elevation.

5.4.2 Oroville Facilities Operations Modeling

The modeling group of the Engineering and Operations Work Group has produced output from models that describe Lake Oroville elevation and water flows and temperatures downstream of Oroville Dam under different operations scenarios. Modeling is a very complex enterprise, in this case using more than 250 sets of daily and monthly synthetic hydrologic data covering the years 1922–1994. (Using data for years before the construction of the Oroville Facilities allows better model simulations.) Several existing models were used to simulate possible effects of future operations on reservoir water levels and temperatures, and river flow and temperatures. Results were relevant to wet, normal, and dry water-year conditions to match the range of possible future hydrologic conditions.

The CALSIM II[4] model simulates the combined operations of the SWP and the federal Central Valley Project under a Coordinated Operations Agreement between DWR and the Bureau of Reclamation. The model allows the operational objectives and obligations under which the Oroville Facilities operate, such as local water demands, Feather River minimum flows, and water exports to SWP contractors, to be taken into account. The key model output for this study is monthly (end-of-month) Lake Oroville elevations. The output of the CALSIM II model is a primary source of input data for the Oroville Facilities' local operations model referred to as HYDROPS[5], and a water temperature model referred to as WQRRS[6].

The HYDROPS model provides hourly and weekly data on reservoir level and river flow specific to the Oroville Facilities under various operational scenarios. It allows modelers to account for both the physical characteristics and constraints of the Oroville Facilities

[4] CALSIM II is a computer model developed by DWR that simulates much of the water resources infrastructure in the Central Valley of California and the Delta region.
[5] HYDROPS is a proprietary model developed by Charles Howard and Associates, Ltd. used for simulation of local operations of the Oroville Facilities.
[6] WQRRS is the Water Quality for River-Reservoir Systems model developed by the US Army Corps of Engineers which simulates water quality in a reservoir, the hydraulics of a river, and the water quality of the river itself.

and desirable operating ranges in terms of flow fluctuation and ramping through the power plants. Along with CALSIM II, HYDROPS provides input data for WQRRS.

The WQRRS temperature model provides output on Lake Oroville's temperature profile and reservoir release temperature, Feather River temperature and flow output, and temperature of diverted flows entering Thermalito Forebay and exiting Thermalito Afterbay back into the river. This model provides information on the likely effects of different operations scenarios on the amount of cold water available in Lake Oroville for release downstream, and the flow and temperature of water released downstream under various operations scenarios.

5.4.3 Operations Modeling Results and Effects on Recreation of Likely Operations Scenarios

As summarized in Section 5.1.1 of this report, conditions at Lake Oroville have varied widely from year to year, largely as a result of different hydrologic conditions. In particular, moderate to severe low water conditions have existed at several times during recent years. For several consecutive years in the early 1990s (1990, 1991, and 1992), the reservoir elevation did not reach above 800 feet and was below 750 feet for much of the year. This occurred again in 2001. Recreation use was likely affected by low water conditions in each of those years. In other years, such as 1994 and 2002, reservoir elevation peaked at well above 800 feet but was below 800 feet for much of the year. The CALSIM II modeling results indicate whether these conditions are likely to occur more frequently or with greater severity.

In addition to whether overall elevation ranges experienced by Lake Oroville visitors in the future are likely to be outside the range of what visitors experienced in the past, learning about potential changes in the timing of reservoir drawdown is also important. A key question to be answered is whether low reservoir levels might occur earlier, on average, during the summer each year. Earlier drawdown could result in more visitors' boating activity and shoreline use being affected because recreation use is greatest at Lake Oroville during mid-May through mid-September period. Therefore, the CALSIM II operations modeling results of most interest include not only the simulated reservoir elevations but the timing of the drawdown below 800 feet or 750 feet, when the most substantial effects on recreation facilities occur.

5.4.3.1 CALSIM II Simulations of Lake Oroville Level as Affected by SWP Demand and Water Year Type

Operations modeling using the CALSIM II model included sensitivity analyses in which Lake Oroville levels at the end of May through August are simulated based on differing water delivery requirements. The current (2002) level of development in the SWP service area was assumed in the water demand inputs to the model. The focus here is on analyses in which the full Table A allotment of 4.2 million acre feet (maf) per year is delivered to SWP Contractors. (Table A water is the maximum contractual amount that

SWP Contractors can request each year. The "full Table A allotment" of 4.2 maf represents the maximum amount of water that currently can be delivered by the SWP.)

Peak Boating Season Boat Ramp Usability

The sensitivity analysis provided data that express the probability of certain Lake Oroville elevations being reached at specific end-of-month dates. The following results describe likely reservoir elevations at the start and end of the peak boating season.

- At the end of May (just after the Memorial Day weekend when the peak boating season generally begins), there is about a 75 percent probability that all five of the developed boat ramps at Lake Oroville, including Enterprise BR, would be usable, and about a 92 percent probability that all but the Enterprise BR would be usable. There is nearly a 100 percent probability that the ramps at Spillway, Lime Saddle, and Bidwell Canyon would be usable.
- At the end of August (just before Labor Day, after which boating use generally drops sharply), there is only about a 28 percent probability that the Enterprise BR would be usable. However, there is about a 60 percent probability that the Loafer Creek BR and all other ramps would be usable and about a 92 percent probability that the ramps at Spillway, Lime Saddle, and Bidwell Canyon would be usable.
- Reduced water deliveries result in higher water levels in Lake Oroville. For example, water deliveries totaling 3 maf rather than 4.2 maf substantially increased the probabilities of boat ramp usability, particularly at the end-of-August period.

Boat Ramp Usability During Different Water Year Types

The modeling results also provide information to compare likely pool elevations during the summer for different types of water years. Water-year types include wet, above normal, below normal, dry and critically dry. Years are classified into water-year type based on a computed index which includes observed and simulated inflows from precipitation and snowmelt and carry-over reservoir storage from the previous year. (Appendix C contains an explanation of the index used to categorize water years for CALSIM II modeling).

In general, the model results showed that Lake Oroville is more sensitive to SWP water demands in drought periods. Specific results based on an assumption of full Table A allotment of 4.2 maf of water delivered to SWP contractors follow:

- During all wet and above normal years and most below normal years, all of the boat ramps with the exception of Enterprise BR would be usable through the end of August.
- During dry years, low water levels would cause the closure of Enterprise BR by the end of June and Loafer Creek BR by the end of August, while the three other ramps would remain usable.
- During some critically dry years, in particular those following dry or critically dry years, all ramps, including those at Spillway, Lime Saddle, and Bidwell Canyon,

would be closed due to low water by the end of August, but would remain open most of the peak boating season.

- The model results indicated that reduced water deliveries totaling 3 maf rather than the maximum 4.2 maf would result in Lake Oroville elevations at which the ramps at Spillway, Lime Saddle, and Bidwell Canyon would remain usable through August during dry years and most critically dry years.

5.4.3.2 CALSIM II Simulations of Future Lake Oroville Water Levels

The primary means by which the effects of future operations on Lake Oroville water levels were assessed was through a comparative analysis using CALSIM II. In a comparative analysis, the model is run twice, once as a baseline and the other with some specific change. In this case, the modeling used the current (2002) level of development/land use (the baseline) and the expected level of development/land use in the SWP service area in the year 2020. Level of development in the SWP service area is a primary determinant of water demand, and level of demand is a primary determinant of annual Oroville Facilities operations. The year 2020 level of development projections were drawn from DWR's most recent California Water Plan Update (Bulletin 160-98). In addition to level of development, the year 2020 model run assumed certain planned changes to SWP and other facilities and expected water demand, regulatory standards, and operations criteria. Climate was assumed to remain unchanged from the 1922–94 historical period used in the model (pers. comm., Hinojosa 2004).

Comparison of the Lake Oroville pool elevation results for these two time periods indicates how reservoir levels are likely to differ in the future. In particular, lower levels during the peak summer boating and reservoir use season or drawdown occurring earlier during the summer would be expected to have substantial effects on boating and other reservoir recreation uses.

The results from the comparative analysis (Table 5.4-1) indicate that reservoir levels will be similar in 2020 to past levels (DWR 2004a). The results indicate that monthly differences in elevation between 2002 and the 2020 would be small, ranging from 1.3 feet higher in January to 4.6 feet lower in October. The average annual elevation for 2020 is projected by the model results to be only about 1 foot higher than the 2002 baseline elevation. However, given the assumptions used in the analysis, it is not advisable to draw precise conclusions about monthly or annual future elevations. It is possible to draw the firm conclusion that future reservoir levels are not likely to change substantially from what has existed in past years.

Table 5.4-1. Comparison of projected end-of-month reservoir levels for Lake Oroville with current (2002) and future (2020) levels of development.

Year	Reservoir Level (ft. msl)											
	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
2002	774.5	778.9	788.5	804.6	821.6	837.3	855.1	862.5	847.6	820.1	792.3	781.2
2020	775.8	781.4	791.1	807.4	824.3	839.4	857.6	864.5	849.5	815.5	790.8	780.3
Difference	+1.3	+2.5	+2.6	+2.9	+2.8	+2.2	+2.5	+2.0	+1.9	-4.6	-1.5	-0.8

Source: DWR 2004a.

The conclusion that reservoir levels will be similary means that the effects of project operations on recreation facilities and activities described in this report are also likely to be similar in the future as to what was observed during the 2002–03 study period. Specifically, key operations effects on recreation such as boat ramp closures due to low water are not likely to be greater or less in the future.

These results have direct implications for future recreation attendance as predicted by the previously discussed Lake Oroville Recreation model. Essentially, future changes in pool elevation indicated by the operations modeling are too small to result in a significant effect on recreation attendance at the magnitude of effect predicted by the recreation model. The percent change in elevation between the 2002 baseline and 2020 is less than one-half of 1 percent each month and less than one-fifth of 1 percent on an annual basis. These elevation changes correspond to predicted recreation attendance changes at Lake Oroville amounting to a small fraction of 1 percent at Lake Oroville.

5.4.3.3 WQRRS Simulations of Feather River Temperatures below the Thermalito Afterbay Outlet

Operations modeling using the WQRRS model included sensitivity analyses which simulated the effects of different flow rates and of different flow temperatures at the Thermalito Afterbay outlet on summer water temperatures in the Feather River from that point and downstream. The model runs did not include the LFC (the Feather River from the Diversion Dam to the outlet). The Project area includes about 4 miles of river below the Thermalito Afterbay outlet. There is interest on the part of some stakeholders to reduce Thermalito Afterbay outlet flow temperatures to help maintain colder temperatures in the river within and downstream of the project to benefit coldwater fish species. The emphasis here is placed on effects within the Project area.

One analysis compared three flow rates at the outlet (600 cfs, 1,000 cfs, and 4,200 cfs) and held the flow temperature constant at 65°F. The flow rates and temperature for the analysis were selected to bracket typical historical conditions. Flows of 1,000–1,200 cfs occurred during the first half of May 2002 and 2003 while flows during June and August of 2002 and 2003 were generally between 3,000 and 5,000 cfs. The typical temperature of the Feather River just above the outlet during mid-summer is 65°F. A

second analysis compared the effect of four flow temperatures (60, 65, 70, and 75°F) at the Thermalito Afterbay outlet, with the flow rate held constant at 1,000 cfs.

The results of the first analysis indicate that increased river flows would have little effect on river temperatures within the Project area under typical summer meteorological conditions (e.g., daytime maximum air temperatures in the low 90s) with (DWR 2003c). Increasing river flows from 1,000 cfs to 4,200 cfs decreased the water temperature by only about 2°F within the Project area. The results of the second analysis indicate that increased outflow temperature only increased river water temperature by about 1–3°F within the Project area under typical summer meteorological conditions. This magnitude of change in temperature may have important effects on fish, but would not affect recreation use.

5.4.3.4 Effects of Increased Flows in the Feather River Low-Flow Channel on Water Temperature and Recreation Use

Operations modeling results are not available for the LFC. However, a three-day increased flow event conducted during August 2002 to benefit the fishery in the LFC (see section 5.2.3.2) provides an opportunity to evaluate the effects of increased flows on water temperature and recreation use. Flows were increased from 700–800 cfs before the event to 1,000–1,750 cfs during the 3 days of the event. Stakeholders have proposed longer-term flow increases of similar magnitude for the LFC to benefit the coldwater fishery.

Hourly water temperature data are available from a DWR-established data collection point at river mile 61.6 within the LFC, about 6.5 miles downstream of the Diversion Dam. Information on effects of the increased flows on recreation is available from field observations and informal interviews with river users conducted during the event. DWR announced the planned increased flows to the public in advance.

Review of the temperature data collected at river mile 61.6 indicates that the daily maximum temperature was lower by about 2°F on the first day of the release event than on the previous day (63°F vs. 61°F). However, the daily maximum water temperature increased on the second and third days of the event to 64 and 65°F, respectively. These temperatures were comparable to the daily maximums during the weeks prior to the event. The daily maximum temperatures occurred about 6 p.m. each day. Daily minimum water temperatures were affected similarly to daily maximums, and were generally 4–7°F below the daily maximums. The daily minimum temperature occurred at about 6 a.m. each day. The conclusion drawn from the temperature data is that increased flow in the LFC of the magnitude described above would have only small effects on water temperature. As stated above, while these changes may have substantial effects on coldwater fish species, they would not have major effects on recreation.

Three field staff visited all of the developed and several undeveloped and dispersed recreation sites along the LFC during the 3-day event to make observations of recreation use and informally interview river users. The observers' overall impression was that the release event increased the number of anglers at the LFC. A total of 115 individual or small groups of visitors were contacted. The visitors were asked three questions:

1) Are you aware of the increased flow in the LFC and, if so, what is your opinion of the water release?

2) Has the water release had any effect on your use of the river today?

3) Do you normally visit the river this time of year and, if so, what is your usual main activity?

Most of those contacted were aware of the increased flow, although some did not know the change was due to a planned release event. Most of the river users observed and contacted were bank anglers who normally fish the Feather River that time of year. A few users were walkers, sightseers, swimmers, and boaters. Several anglers said they had been drawn to the river that day because of the increased flows, and several felt it had improved the fishing that day. Others said it hadn't affected their fishing that day or made it worse, but some of these anglers believed the release would improve the fishery in the longer term (after the release event). A few anglers commented that it was harder to wade into the river with the higher flows.

At the downstream end of the LFC near the Thermalito Afterbay outlet, some bank anglers complained about the negative effects of more aquatic vegetation, snags, and tree limbs that accumulated there after being washed downstream. Many of the anglers at the outlet fish on the outlet structure (technically trespassing), and complained that the reduced flow from the outlet had a negative effect on their fishing. (The increased flow being diverted down the LFC reduced the flow through the Thermalito Forebay and Afterbay complex and at the Thermalito Afterbay outlet by the same amount.)

Swimmers and walkers at Bedrock Park commented that the increased flows were beneficial in flushing out aquatic weeds, stagnant water, and dead fish from the small swimming hole there. (The swimmers were not swimming during the release event but swimming is usually their primary reason for coming to the LFC.) Some flooding of walking paths along the LFC at Bedrock Park during the event affected trail users.

The LFC does not receive high amounts of boating use, and there were few opportunities to contact boaters during the release event. However, one visitor commented that he liked the high water level and would prefer a consistent high flow similar to what occurred during the release event to improve kayaking on the river.

Another visitor commented that she had never seen boats on the river near Bedrock Park like were there during the flow event.

The overall impression obtained from river users' comments during the increased flow event was that the increased flows improved recreation opportunities for anglers, who are the primary users. Angling success seemed to be improved or unaffected for those who knew how to adjust to or take advantage of the conditions. Some anglers felt the increased flows were bad for fishing in the immediate term, and preferred to return after flows returned to normal. Anglers fishing (illegally) on the Thermalito Afterbay outlet structure did not like the effect of the decreased outlet flows on their fishing. Swimmers felt the flow event would improve conditions at the Bedrock Park swimming hole. (No data are available, but increased flow at the Bedrock Park swimming hole might also reduce the water temperature, which would be undesirable for swimming.)

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6.0 SUMMARY AND DISCUSSION

The main objective of this study is to determine the effects of current project operations and any proposed changes to project operations on recreational use and recreational experiences of visitors pursuing various activities. In meeting that objective, the study has used historical data to document project conditions such as reservoir pool levels and temperatures and river flows and temperatures that may have effects on recreation. The effects of these factors on recreation activities such as boating, reservoir shoreline use, swimming, and angling were observed and documented in the field between May, 2002 and May, 2003. In addition, recreation visitors to the Oroville Facilities were surveyed to obtain information on their experiences and perceptions related to the study objective. Statistical models were used to investigate the effects of reservoir pool levels, among others factors, on recreation attendance. Operations modeling was used to simulate likely future Lake Oroville pool levels and associated effects on recreation facilities based on historical hydrological conditions and future water facilities, management, and use patterns. Operations modeling was also used to investigate the potential for operational changes to affect Feather River water temperatures.

The major findings resulting from these data sources related to specific portions of the Oroville Facilities and types of recreation facilities are summarized below. Lastly, the implications of project operations for recreation are summarized.

6.1 LAKE OROVILLE ISSUES AND EFFECTS OF PROJECT OPERATIONS

Reservoir elevation is the primary operations issue for Lake Oroville, especially during the summer. The water level has historically varied greatly from year to year, depending on inflow into the reservoir and the amount of water released to meet downstream demands and regulatory requirements. From 1990 to 2002, the reservoir pool was below 800 feet for the entirety of four of those years and was above 800 feet for most of six of those years. In the remaining three years, reservoir pool level ranged both above and below 800 feet. The effects of water level on recreation vary greatly from year to year.

Recreation modeling conducted for Study R-12 – *Projected Recreation Use* has identified water level as a significant factor in overall visitation to Lake Oroville. However, high pool levels have not always resulted in high attendance and low pool levels have not always resulted in low attendance.

6.1.1 Effects on Boat Ramps

Effects on boat ramps are among the most visible and important effects of low water at Lake Oroville. However, with the December, 2002 extension of the major boat ramps at Lime Saddle, Spillway, and Bidwell Canyon, boat access will likely be available during all but the lowest water periods, when the pool level drops below 695 feet. Pool elevations below 700 feet are an uncommon occurrence; prior to 2002, when the lake

was below 700 feet for about 30 days during November and December, this had not occurred since March, 1991.

As the reservoir elevation falls, the number of ramp facilities and the total number of ramp lanes available decreases. A total of 33 launch lanes are available lake-wide when the reservoir pool level is high (within about 50 feet of the full pool elevation of 900 feet). At moderate pool levels (between 850 and 800 feet), there are 25 to 31 lanes available. From 12 to 17 lanes are open at low pool elevations, down to about 725 feet. Below 725 feet, there are only seven remaining lanes, and all lanes are closed when the pool drops below 695 feet. In terms of the percentage of peak season days that boat ramps were unusable due to low pool elevation, two boat ramps had particularly high rates from 1990 to 2002: Enterprise (53 percent) and Loafer Creek (33 percent).

Access to parking areas from most of the ramps becomes increasingly difficult for boaters as the reservoir pool level drops and the steep walk up the ramp from the boat to the vehicle lengthens. The Spillway boat ramp is unique in that it provides a large, seasonally inundated, paved parking area adjacent to the low-water ramp.

6.1.2 Effects on Car-Top Boat Ramps

Car-top boat ramps are also affected by low water, most significantly below 800 feet, when the water becomes too distant and the shoreline too steep for most car-top boaters, bank anglers, and other shoreline users at some sites. Dark Canyon Car-Top BR is primarily used by boaters rather than shoreline users, and launching of boats is possible well below 800 feet. At Vinton Gulch Car-Top BR, conditions for shoreline use and car-top boat launching are good until the reservoir level falls below about 830 feet. Small boats may be trailer-launched down to about 850 feet. Nelson Bar Car-Top BR is more severely affected by low water, with most boat launching and shoreline use becoming undesirable or infeasible below about 840 feet.

Foreman Creek Car-Top BR and Stringtown Car-Top BR provide more opportunities for shoreline recreation as the reservoir level falls than do other facilities of this type. Foreman Creek provides a large area of flat to gently-sloped land that becomes exposed as the reservoir pool level drops below 850 feet. A gently-sloping paved road bed extends far out into the inundation zone. Shoreline activity and boat launching are possible well below 800 feet but become less desirable or difficult below 775 feet. The Stringtown Car-Top BR also provides a large area of exposed shoreline as the reservoir level falls, although it is steeper than at Foreman Creek. The road bed that is exposed as the water recedes allows launching of small boats below 800 feet. Steep and muddy shorelines make shoreline use less desirable below 800 feet.

6.1.3 Effects on Boat-in Campsites, Swimming Facilities and Opportunities

The boat-in campsites are usable at any reservoir elevation, but become progressively less desirable to boaters (who have to carry their camping equipment and supplies farther) as the reservoir pool level falls. For this reason, use of the boat-in campsites,

which is usually low at all elevations, is very low when the lake elevation falls below approximately 830 feet.

The only developed swimming beach at Lake Oroville is at the Loafer Creek DUA. The facility is unusable as designed at reservoir elevations below about 860 feet. The small cove on which the facility sits becomes dewatered below that pool elevation. This condition occurs most summers at Lake Oroville with the facility being unusable by about mid-June most years. Swimming also occurs at car-top boat ramps but, as described above, is made more difficult and less desirable (as is other shoreline use) at reservoir levels below about 800 feet. Some visitors to Lake Oroville go to the North Forebay DUA swim beach when swimming opportunities on the lake (for non-boaters) are limited by low-water conditions.

6.1.4 Visitor Survey Data Related to Effects of Project Operations

About half of the Lake Oroville visitors surveyed considered water level fluctuations and exposed land and shallow areas during low water to be a “moderate” or “big problem.” About one-third considered access to the shoreline to be a “moderate” or “big problem.”

A high percentage of Lake Oroville boaters indicated they were satisfied with their boating experience. However, many of those who were not satisfied mentioned low water conditions as a direct or indirect cause of their dissatisfaction. Satisfaction with fishing experiences was somewhat lower, but fewer anglers pointed to low water as the cause of dissatisfaction. (The best fishing conditions, and most fishing tournaments, occur at Lake Oroville during the fall and winter, when reservoir pool levels are usually lowest.) Bank anglers who were confronted with the low water levels of summer 2002 were more likely to express dissatisfaction with those conditions.

Numerous written comments were received by boaters, anglers, and other lake users that provided specific observations and opinions of the negative effects of the low water levels they experienced during the 2002 summer and fall season. The most common comments related to aesthetic effects, effects on boating facilities, safety, and enjoyment, and a lack of shoreline areas to use for swimming and other uses when the lake is low. These comments may provide some guidance for future management of Lake Oroville recreation facilities during the expected low-water periods that are likely to occur most years.

6.2 THERMALITO DIVERSION POOL, THERMALITO FOREBAY AND THERMALITO AFTERBAY ISSUES AND EFFECTS OF PROJECT OPERATIONS

Water levels are essentially stable in the Diversion Pool and Forebay, and stay within a 5–6 foot range during a weekly fluctuation cycle at Thermalito Afterbay. As a result, water level changes have little effect on boating, swimming, or other shore-based activities at these areas. The main issue is water temperature, which during the summer months ranges from the 50s (°F) in the Diversion Pool and Forebay to the 60s in most of Thermalito Afterbay.

The cold water temperatures in the Diversion Pool, Forebay, and Afterbay are a result of the water being released from Lake Oroville into the Diversion Pool at a consistent temperature of about 45–50°F. The purpose of maintaining low water temperature downstream is to meet the requirements of the Feather River Fish Hatchery, which draws water from the Diversion Pool, and the needs of coldwater fish species (i.e., salmon and steelhead) in the Feather River. Coldwater fish species in all three of these water bodies also benefit. However, temperatures in these water bodies are colder than what most recreationists would desire for water-contact recreation. Agricultural users of water stored in Thermalito Afterbay are also interested in warmer water during the growing season.

The location of the North Forebay DUA swim beach on a shallow embayment, separated from the main flow of colder water coming from the power canal, usually provides warmer water for wading and swimming. The surface water temperature was found to be in the mid-70s (°F) during the late summer of 2003. The water below 1 meter in depth remained at colder temperatures, similar to those found elsewhere in Thermalito Forebay.

Two recreation facilities on Thermalito Afterbay also provide swimming opportunities. The small beach adjacent to the Monument Hill boat ramp provides picnic tables and sandy shoreline and is popular with swimmers as well as users of PWC, despite the cool water temperatures. The Larkin Road Car-Top BR does not provide a beach or picnic tables but is also popular with PWC users. This facility is close to the Thermalito Afterbay outlet, where the highest water temperatures in Thermalito Afterbay are found.

6.3 FEATHER RIVER ISSUES AND EFFECTS OF PROJECT OPERATIONS

As described above, water released from Lake Oroville is maintained at 45-50°F, largely to meet the needs of coldwater fish species in the Feather River Fish Hatchery and the Feather River. This is colder water than was present in the river during the summers before the Oroville Facilities existed. The maximum daily summer water temperature measured in the Feather River below the Diversion Dam (about 4 miles below the dam) is from 7 to 12°F cooler than before construction of Oroville Dam (DWR 2001).

The water warms slightly as it moves down the Feather River. Maximum summer temperatures in the LFC are generally in the mid- to upper 50s (°F) at the upstream end near the Diversion Dam and increase to the mid- to upper-60s at the lower end, above the Thermalito Afterbay outlet (about 10 miles downstream). Temperature increases cumulatively below the outlet. As discussed above, water of these temperatures are colder than preferable for swimming, and relatively little swimming occurs in the river. However, anglers commonly wade to fish in the river, usually with the protection of rubber waders.

Flow rates in the river below the Thermalito Afterbay outlet are also regulated to meet the needs of the fishery. High flows in the river below Thermalito Afterbay may make wading more difficult for anglers, but they tend to adjust to those conditions by staying in shallower water or by fishing from the bank or gravel bars. High flows may also make boating more challenging, but field observations indicate that anglers who boat on the river during the prime late summer and fall fishing season are not deterred from using this very popular fishery resource.

6.4 EFFECTS OF OPERATIONS UNDER FUTURE OPERATIONAL SCENARIOS

Recreation modeling results indicate a significant negative effect on Lake Oroville visitation levels from low Lake Oroville pool levels and a smaller positive effect on visitation at Thermalito Forebay. However, the operations modeling results indicated that future reservoir levels are likely to be similar to historical levels. The modeling results provide no indication of higher or earlier drawdown of the reservoir than has occurred in the past. Therefore, both future recreation attendance (to the extent that it is affected by Lake Oroville pool levels) and future low-water effects on recreation facilities and activities are expected to be similar to that historically observed.

Operations modeling that focused on water temperature in the Feather River indicated that operational changes altering the temperature or flow rate of water released to the river from Thermalito Afterbay would affect water temperatures in the river within the study area by only a few degrees. Water temperatures in the river are lower than desirable for swimming and other water-contact recreation, and the modeling based on plausible operational ranges indicates it is likely to remain so. Fisheries-related and other environmental constraints impose narrow constraints on the water temperatures allowed in the river. The limitations are not favorable for water-contact recreation in the river but are critical to the success of the fishery, which supports the dominant recreation activity of angling for coldwater fish species such as trout and salmon.

Observation of recreation use and informal interviews with river users during a 3-day period of increased flows in the LFC of the Feather River provided an indication of the likely effects of similar proposed operational changes on recreation. (The increased flow event was a one time test carried out as part of fisheries studies being conducted under the purview of the Environmental Work Group.) The release of additional water from the Diversion Pool into the river increased flows at the peak of the event by a factor of 2.5. The increased flows appeared to attract some anglers who had heard about the event in advance, and most felt it was beneficial for angling either during the event or in the longer term. Some anglers were concerned that the increased flows made wading in the river more difficult. Other river users, such as walkers on riverbank trails and swimmers, were generally unaffected and noted beneficial results of the increased flows due to flushing out of aquatic weeds and other debris. Boating activity appeared to increase on the river during the release event. Water temperature was affected only slightly by the increased flows.

6.5 SUMMARY OF KEY EFFECTS OF OPERATIONS FOR RECREATION

This report has described how the moderate or low-water Lake Oroville pool levels that result from normal operations most years affect the usability of recreation facilities and recreation opportunities. Effects are most severe during low-water years (drought periods), when low reservoir levels often persist through all or most of the peak summer recreation season. However, during the highest water years, these reservoir levels and effects primarily occur during the fall through early-spring non-peak use season.

Reservoir levels below 800 feet result in a significant reduction of the number of launch lanes available at specific sites and throughout the reservoir, and shoreline access for non-boaters is difficult at most sites. However, several boat launching facilities are usable down to pool levels of 700 feet and slightly lower. These very low pool levels occur only rarely and generally during the winter when recreation activity is low. Also, several of the car-top boat ramps provide opportunities for launching of small boats and shoreline recreation in an undeveloped setting, even at pool levels well below 800 feet.

This report has described water temperature as the primary effect of operations on the Thermalito Diversion Pool and Thermalito Forebay. The fact that the temperature of these water bodies (below 60°F through the summer) is lower than desired for swimming and other water-contact recreation must be balanced against the needs of coldwater fish species and the needs of the Feather River Fish Hatchery. During the summer, the embayment where the North Forebay swim beach is located hosts a large number of swimmers, and has considerably warmer surface water than other sites (although the water more than one meter below the surface remains cold).

Daily pool level fluctuations at Thermalito Afterbay can affect boaters who are unaware of areas that become too shallow to navigate when the pool level is at the lowest part of the weekly cycle. Summer water temperatures are cool in Thermalito Afterbay but are as much as 10°F warmer than Thermalito Forebay, providing generally acceptable conditions for swimming, water-skiing, PWC use, and other forms of water-contact recreation.

As at Thermalito Diversion Pool and Forebay, the Feather River's coldwater fish species need lower water temperatures than are desirable for water-contact recreation. Current operations result in water temperatures 7–12°F lower than the summer maximum temperatures that existed prior to construction of the Oroville Facilities. The coldwater fishery is important to anglers, who make up the primary user group on the river. Average summer flows in the low-flow channel of the river are lower than those that occurred before the Oroville Facilities were constructed (Sommer et al. 2001), but are generally sufficient to allow non-motorized boating. Increased flows to benefit the fishery may be to the advantage of some types of boating but may make wading more difficult for anglers.

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7.2 PERSONAL COMMUNICATIONS

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APPENDIX A

SUPPLEMENTAL SURVEY FORM

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SUPPLEMENTAL SURVEY FORM
Effects of Lake Oroville Water Levels on Recreation

1. In the on-site survey, you said you were a regular recreation visitor to the Lake Oroville area. During the last **3 years**, about how many times have you visited Lake Oroville?	_____VISITS
2. During those visits, did you experience what you **personally** considered low lake levels and, if yes, how many times? *If you DID NOT experience low lake levels,* ***skip to Question 9****.*	_____ YES → _____ TIMES _____ NO → ***skip to Q9***
3. During how many of those visits with low lake levels did you **boat** on Lake Oroville? *(You do not have to have been the boat driver, just been on a boat.)*	_____ VISITS
4. Now, we want to ask about the **most recent experience** you may have had with low water conditions at Lake Oroville. Do you remember when that was? *(An approximate date is OK, but please identify at least the week of the visit, e.g. "last week August 2002")*	DATE: _____
5. Did you boat on the lake during that visit? *If you DID NOT boat,* ***skip to Question 7****.*	_____ YES _____ NO → ***skip to Q7***
6. The following questions relate to that boat outing:	
a. From what boat launch ramp or marina did you access the lake on your most recent visit?	RAMP or MARINA: _____
b. Did you have difficulty **launching** the boat due to low lake levels?	_____ YES _____ NO _____ Didn't launch
c. Did boating conditions feel more **crowded** than when the water was higher?	_____ YES _____ NO _____ Not sure
d. Were you more concerned about the **safety** of boating on the lake than when the water was higher?	_____ YES _____ NO
e. Did the water level have any other effects on your boating? *If YES, what other specific effects?* _____ _____ _____	_____ YES _____ NO
Please turn to other side…	
Now, a few questions about your use of the shoreline during that visit:	

7. Did you use the shoreline of Lake Oroville to fish, picnic, swim or do other **non-boating** activities? *If NO,* ***skip to Question 8****.*	_____ YES _____ NO → ***skip to Q8***
a. What area(s) of shoreline did you use? _____ _____	*Please be as specific as you can in naming or describing the location(s) (e.g., "Foreman Creek area")*
b. Did you have difficulty getting to the shore?	_____ YES _____ NO
c. Did you find it difficult to use or enjoy the lake shoreline to swim, picnic, relax, etc. at that location?	_____ YES _____ NO
d. Were there any other effects of low water levels on your shoreline use? *If YES, please specify:* _____ _____ _____	_____ YES _____ NO
Just two additional questions:	
8. How much did the **appearance** of the exposed shoreline detract from your visit on the date listed in Question 4? *(check one)* ___ Not at all ___ Slightly detracted ___ Moderately detracted ___ Greatly detracted	
9. Whether or not you personally experienced low lake levels, are there actions that you think could be taken to reduce the effects that reservoir drawdown has on recreational use of Lake Oroville? If yes, what are they? *(Please describe below)* _____ _____ _____ _____	_____ YES _____ NO

Thank you very much for taking the time to answer these additional questions…Please return the survey right away in the envelope provided.

APPENDIX B

DAILY LAKE OROVILLE ELEVATION DATA: MAY 2002 – MAY 2003

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Daily Lake Oroville Elevation Data, May 2002–May 2003

DAY	Lake Oroville Elevation (ft. msl)												
	May 02	Jun 02	Jul 02	Aug 02	Sep 02	Oct 02	Nov 02	Dec 02	Jan 03	Feb 03	Mar 03	Apr 03	May 03
1	838.23	837.38	812.76	769.66	734.15	717.88	702.87	696.19	746.49	798.15	806.18	837.39	870.72
2	837.96	837.87	811.29	768.24	733.13	717.47	702.36	695.86	748.05	799.91	806.81	837.74	872.07
3	837.54	837.67	809.96	767.04	732.24	717.21	701.80	695.49	749.24	801.24	807.03	838.51	874.18
4	837.87	837.08	808.62	766.19	731.41	716.73	701.19	695.08	750.35	802.33	807.26	839.36	876.37
5	838.35	836.20	807.14	764.97	730.70	715.95	700.61	694.57	750.89	803.57	807.31	840.19	878.17
6	837.99	835.59	805.65	763.79	730.22	715.16	700.04	694.03	751.81	804.70	807.57	841.14	880.00
7	837.87	834.68	804.14	762.35	729.59	714.71	699.93	693.40	752.63	805.49	807.93	841.79	881.49
8	837.59	834.18	802.72	761.10	729.47	714.17	700.38	692.81	753.31	806.50	808.41	842.44	882.99
9	837.33	834.01	801.23	759.62	728.67	714.02	700.84	692.14	754.33	807.40	808.71	843.00	883.99
10	837.18	833.18	799.79	758.50	727.99	713.84	701.14	691.43	755.97	808.23	809.33	843.59	885.40
11	837.38	832.36	798.37	757.55	727.14	713.47	701.28	690.85	758.90	808.34	809.88	844.30	886.66
12	838.41	831.33	796.72	756.01	726.18	713.34	701.08	690.38	761.15	808.15	810.36	845.49	887.59
13	837.93	830.22	795.83	754.66	725.59	713.09	700.67	690.85	763.73	808.11	810.73	847.13	888.57
14	837.32	829.08	794.93	753.66	725.42	712.95	700.30	697.68	766.12	808.31	812.06	848.35	889.35
15	837.06	828.22	793.39	752.39	725.32	712.63	700.21	701.92	767.81	808.67	816.36	849.27	890.50
16	836.70	827.86	791.79	751.14	724.39	712.29	699.96	707.94	769.17	809.12	819.20	850.18	891.44
17	836.28	826.84	789.93	750.39	723.40	711.98	699.62	710.57	770.43	808.90	820.89	851.15	892.50
18	836.53	825.60	788.40	749.85	722.98	711.48	699.35	711.85	772.04	808.68	822.21	852.16	893.45
19	837.10	824.46	786.96	748.55	722.20	710.71	698.94	713.15	773.50	808.66	823.30	853.51	894.08
20	836.94	823.51	785.85	747.42	721.60	710.39	698.52	714.42	774.64	808.47	824.00	854.62	894.60
21	836.85	822.85	784.96	745.85	721.42	709.71	698.42	717.34	775.69	807.90	825.47	855.58	895.01
22	836.70	822.38	783.66	744.42	721.46	709.16	698.33	718.68	777.11	807.54	826.14	856.34	895.40
23	836.61	821.84	782.16	742.90	720.65	708.51	698.41	718.97	780.61	807.81	827.55	857.18	895.85
24	836.53	820.84	780.68	742.18	719.99	707.88	698.20	719.62	783.47	807.04	828.72	858.88	896.55
25	836.59	819.79	779.28	741.77	719.40	707.27	698.20	720.39	786.13	806.45	829.28	860.58	897.13
26	837.44	818.63	777.57	740.71	718.60	706.74	697.84	720.93	788.22	806.71	830.83	862.51	897.55
27	837.62	817.30	776.25	739.56	718.45	705.86	697.53	724.74	789.97	806.38	832.23	864.04	897.65
28	837.47	815.87	775.35	738.29	718.60	705.26	697.14	733.05	791.98	805.96	833.38	865.76	897.69
29	837.33	814.77	774.05	737.07	718.89	704.60	696.77	738.38	793.61		834.46	867.50	897.69
30	837.21	814.00	772.56	735.74	718.30	703.95	696.41	741.23	795.10		835.87	869.13	897.94
31	837.14		771.15	734.74		703.34		744.23	796.56		836.75		898.42

Source: DWR 2003a.

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APPENDIX C

WATER YEAR CLASSIFICATION SYSTEM USED FOR OPERATIONS MODELIING

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Most of this information is adapted from *Preparing for California's Next Drought* (DWR 2000). Specific water year classification values were drawn from the State Water Resources Control Board website at:
http://www.swrcb2.ca.gov/plnspols/wqplans/deltwqcp.doc

Water year classification systems provide a means to assess the amount of water originating in a basin. Because water year classification systems are useful in water planning and management, they have been developed for several hydrologic basins in California. One such system is the Sacramento Valley 40-30-30 Index, which was used in classifying water years for Oroville Facilities operations modeling.

The Sacramento Valley 40-30-30 Index was developed by the State Water Resources Control Board (SWRCB) for the Sacramento River hydrologic basin as part of SWRCB's Bay-Delta regulatory activities. The system defines one "wet" classification, two "normal" classifications (above and below normal), and two "dry" classifications (dry and critical), for a total of five water year types.

The Sacramento Valley 40-30-30 Index is computed as a weighted average of the current water year's April-July unimpaired runoff forecast (40 percent), the current water year's October-March unimpaired runoff forecast (30 percent), and the previous water year's index (30 percent). A cap of 10 maf is put on the previous year's index to account for required flood control reservoir releases during wet years. Unimpaired runoff (calculated in the 40-30-30 Index as the sum of Sacramento River flow above Bend Bridge near Red Bluff, Feather River inflow to Oroville, Yuba River flow at Smartville, and American River inflow to Folsom) is the river production unaltered by water diversions, storage, exports, or imports.

Using the 40-30-30 Index, water years are classified as follows:

Classification	Millions of Acre-Feet (maf)
Wet	equal to or greater than 9.2
Above Normal	greater than 7.8 and less than 9.2
Below Normal	equal to or less than 7.8 and greater than 6.5
Dry	equal to or less than 6.5 and greater than 5.4
Critical	equal to or less than 5.4

By considering water availability from storage facilities as well as from seasonal runoff, the 40-30-30 Index provides a representative characterization of water year types. However no indexing scheme can be a perfect representation of water year type. For example, the inability to store large volumes of wet year runoff (due to reservoir flood control requirements and the relatively low ratio of storage capacity to wet year runoff volumes for most California rivers) distorts the 40-30-30 Index value for the year following a very wet year.

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